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PLANT PERFORMANCE AT THE OWENS-CORNING FIBERGLAS CORPORATION. WASTEWATER TREATMENT FACILITY, ANDERSON, SOUTH CAROLINA, MARCH 1973-MAY 1973

National Field Investigations Center-Cincinnati, Ohio

December 1973

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The cooperative support of the plant management and treatment facility operating personnel of the Owens-Corning Fiberglas Corporation, Anderson, South Carolina, is gratefully acknowledged.

Report Of The
Technical Support Project
At The Owens-Corning Fiberglas Corporation
Wastewater Treatment Facility
Anderson, South Carolina
March 1973 - May 1973

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Office of Enforcement & General Counsel
National Field Investigations Center
Cincinnati, Ohio

December 1973

INTRODUCTION

This report describes the results achieved during the federal technical support project conducted at the Owens-Corning Fiberglas Waste Treatment Facility, Anderson, South Carolina. Personnel of the Waste Treatment Branch, National Field Investigations Center - Cincinnati, assisted the Fiberglas personnel in developing operational control techniques to improve the performance of their waste treatment facility. The request for assistance originated with the Corporate Office of Owens-Corning, Toledo, Ohio, through the South Carolina Pollution Control Authority, the Environmental Protection Agency Region IV, and was approved by the Office of Enforcement and General Counsel, Environmental Protection Agency.

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SUMMARY

The Waste Treatment Group, National Field Investigation Center - Cincinnati (NFIC-C), has trained Owens-Corning Fiberglas plant operators in the utilization of the NFIC-C Operational Control Procedures to complement their experience and knowledge of their facility. Operators were shown how to calculate control adjustment demands from sludge quality and process status tests. They were also taught how to display essential test data and process relationships to permit analysis of process response to control adjustments. Numerous parameters have been calculated, tabularized, and/or plotted to complete the evaluation of plant loadings and process response to control adjustments. This type of evaluation must continue as a part of obtaining "best effluent". In addition recommendations have been made to highlight problem areas which were noted during the technical support project.

As the project progressed and operator skill was acquired a "consistency" of final effluent quality was attained. The data also displays the plant's improved ability to withstand the "shock loads" which were experienced during the project.

The following table summarizes the loadings and treatment accomplished during the final 77 days of the technical support project:

TABLE NO. 1

BOD 5, SUSPENDED SOLIDS, AND SECONDARY PROCESS LOADING SUMMARY - FINAL 77 DAYS OF PROJECT

	WORST WEEK	77 DAY AVERAGE	BEST WEEK
NUMBER OF DAYS	7	77	7
STARTING	4/24/73	3/19/73	5/27/73
ENDING	4/30/73	6/ 3/73	6/ 2/73
FLOW			
CU M/DAY	2323	2373	2440
MGD	0.6136	0.6269	0.6446
BOD 5 CONCENTRATIONS (mg/l)			
RAW	544	385	397
PRIMARY EFFLUENT	462	323	373
FINAL EFFLUENT	45	17	12
BOD 5 REDUCTIONS (%)			
PRIMARY	15.2	16.4	6.0
SECONDARY	91.5	94.8	96.8
PLANT	92.8	95.6	97.0
TSS CONCENTRATIONS (mg/l)			
RAW	381	462	398
PRIMARY EFFLUENT	142	139	129
FINAL EFFLUENT	26	16	10
TSS REDUCTIONS (%)			
PRIMARY	62.6	70.3	68.2
SECONDARY	84.1	88.0	86.7
PLANT	93.8	96.4	97.5
SECONDARY LOADINGS			
ADT @ AFI (hrs)	16.5	16.1	15.7
ADT @ TFL (hrs)	10.6	10.6	11.0
G BOD 5/CU M	680	477	558
LB BOD 5/1000 CU FT	42.5	29.8	34.9
OFR (cu m/sq m/day)	16.6	17.0	17.5
OFR (gal/sq ft/day)	409	418	430

RECOMMENDATIONS

The following recommendations are made in order that the Owens-Corning Fiberglas Corporation Waste Treatment Facility can produce a consistently high-quality final effluent:

1. Continue to use the NFIC-C Operational Control Procedures demonstrated during the technical support project.

2. Use process demands to determine return sludge and waste sludge requirements.

3. Install a recording-totalizing waste sludge flow meter.

4. Provide improved screening and grit removal equipment.

5. Improve the pH adjustment system, especially the caustic feeding part of the system.

6. Resolve the problem of handling the highly concentrated organic batch dumps. Possible alternatives are repiping to utilize one of the existing mixing tanks to hold batch dumps and later "bleed" them into the system or the acquisition of a tank trailer to hold dumps for bleeding into the system.

7. Problem wastes should be categorized. These should include the highly concentrated organic wastes and those with extremely high or low pH values. Those dumps which have given no operational control problems historically should also be identified so that the operator can identify those dumps which will require no special operational adjustments. A general awareness of the problem wastes should be communicated to personnel in the area from which these flows originate.

8. Modify the blower system so that it can provide sufficient air under changing conditions.

9. Consider using a recording D. O. analyzer in the aeration tanks.

10. Install a positive control device in the distribution box between the aeration tanks and the clarifiers so that mixed liquor can be distributed to the clarifiers without pulsing and air entrainment.

11. Use only two secondary clarifiers if plant flow remains at the level observed.

12. Reevaluate the secondary clarifier inlet piping that is reducing chemical treatment effectiveness. Consider returning to the original inlet port and target plate configuration.

13. Investigate the possibility of eliminating the sludge lagoon and of disposing of sludge by other means.

14. Consider an improved ferric chloride feed system. This should at least include improved drum handling techniques for safety, or consideration of bulk storage, pumps and piping to add iron to either the distribution box or the flocculation tank.

15. Consider adding a second polymer mixing tank and an adjustable, positive-displacement pump in the secondary coagulant aid system.

16. Improve the nutrient addition system to give the operator the ability to adjust and maintain required feed rates.

TREATMENT FACILITIES

The Fiberglas facility is a conventional, activated-sludge plant designed to treat the wastes generated by the fiberglass factory and by a small chemical plant. It also processes the domestic wastes from the factory.

FLOW PATTERN

Waste flows to the facility in two lines as shown in Figure 1. The "mat line" from the fiberglass mat production area injects wastes into the smaller mixing tank through a basket intended to capture fiberglass strands. Sludge lagoon surface water, when pumped, flows into this same line. Wastes from the chemical factory and other production areas flow into the larger mixing tank via the second line.

Waste is continuously pumped from the larger to the smaller mixing tank which overflows into a distribution box. Most of the waste from the distribution box then flows through the flash mixing tank into the flocculation tank; the remaining flow from the distribution box is directed back to the larger tank. Continuous pH monitoring is provided at the flocculation tank.

From the flocculation tank the waste is distributed to five primary clarifiers, whose effluents flow by gravity to a wet well where they are combined with return sludge and then pumped to the three diffused air aeration tanks.

Aeration tank effluents flow by gravity through a distribution box, which proportions the flow to three rectangular secondary clarifiers. The clarifier effluents flow through a Parshall Flume into a wet well and are then pumped into an irrigation pond. The pond overflow is discharged to Drake Creek.

Primary sludge is pumped into an aerobic digester which is periodically drained to a sludge lagoon. The sludge which settles in the secondary clarifiers is pumped to the wet well ahead of the aeration tanks, and excess sludge is wasted to the flocculation tank.

The facility is provided with two coagulant aid systems. The first system permits adding coagulant to the flocculation tank just ahead of the primary clarifiers. In the second system, this is accomplished at the distribution box following the aeration tanks.

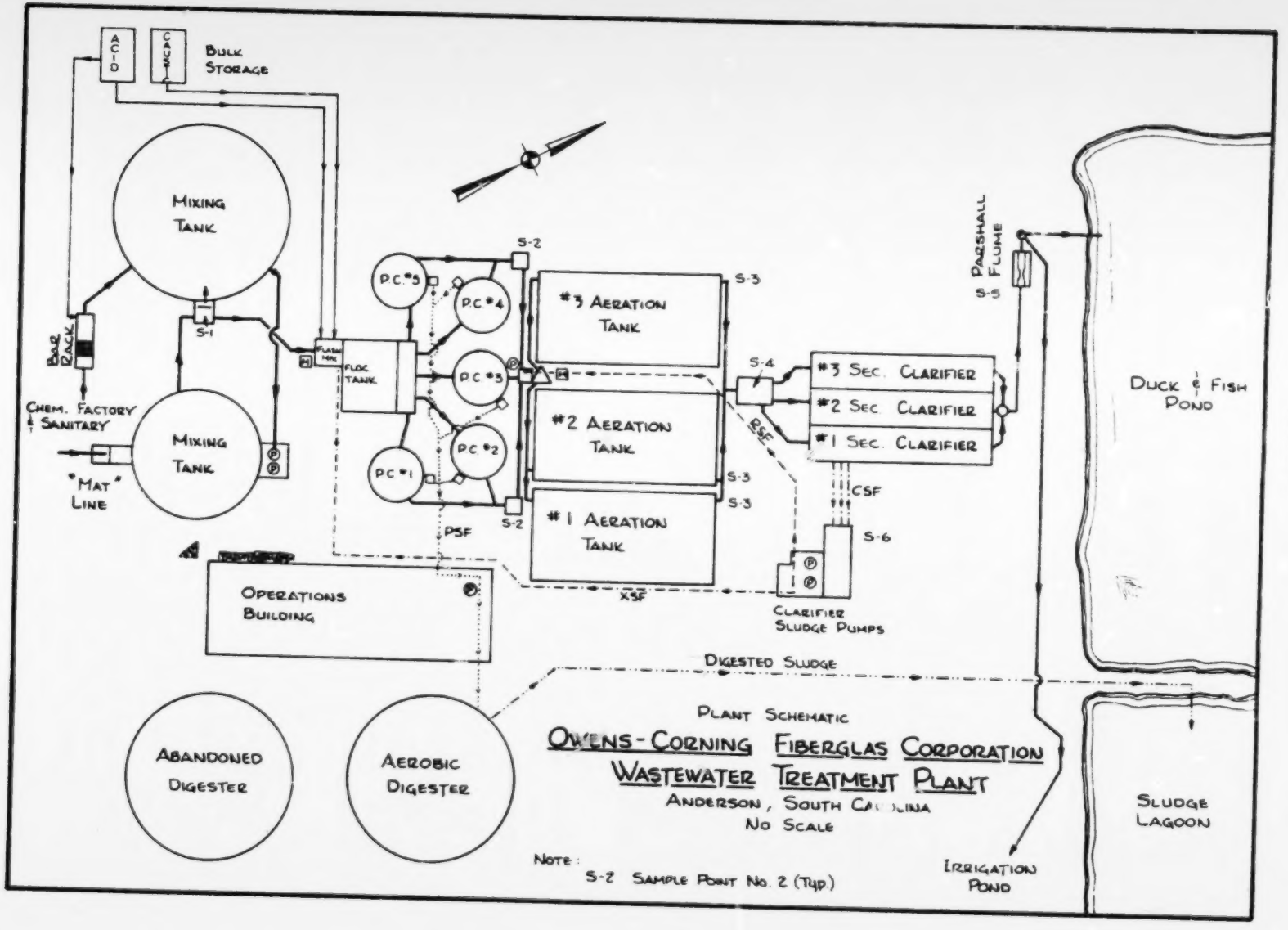

ACID
CAUSTIC
BULK STORAGE
MIXING TANK
BAR RACK
S-1
CHEM. FACTORY & SANITARY
MIXING TANK
"MAT" LINE
FLASH MIX
FLOC TANK
P.C. #5
P.C. #4
P.C. #3
P.C. #2
P.C. #1
S-2
PSF
#3 AERATION TANK
#2 AERATION TANK
#1 AERATION TANK
S-3
S-4
#3 SEC. CLARIFIER
#2 SEC. CLARIFIER
#1 SEC. CLARIFIER
CSF
XSF
S-6
CLARIFIER SLUDGE PUMPS
PARSHALL FLUME
S-5
DUCK & FISH POND
OPERATIONS BUILDING
DIGESTED SLUDGE
ABANDONED DIGESTER
AEROBIC DIGESTER
SLUDGE LAGOON
IRRIGATION POND
PLANT SCHEMATIC
OWENS-CORNING FIBERGLAS CORPORATION
WASTEWATER TREATMENT PLANT
ANDERSON, SOUTH CAROLINA
NO SCALE
NOTE:
S-2 SAMPLE POINT NO. 2 (TYP.)

FIGURE 1

A temporary ferric chloride feeding system was provided for the project. Ferric chloride was pumped from 55 gallon drums directly to the distribution box following the aeration tanks.

DESIGN CRITERIA

The consulting engineers' design figures (Table 2) define the total plant capacity as 3,785 cu m/day (1 mgd) of industrial waste at 450 mg/l or 1,704 kg/day (3,753 lb/day) of 5-day BOD.

The sizes and capacities of the treatment facility units are listed in Table A-1.

TABLE 2

CONSULTING ENGINEERS' DESIGN CRITERIA

FLOW	3785 cu m/day (1 mgd)
BOD 5 CONCENTRATIONS	
RAW	450 mg/l
PRIMARY EFFLUENT	200 - 300 mg/l
BOD 5 LOAD	
RAW	1704 kg/day (3753 lb/day)
SECONDARY	757 - 1136 kg/day (1668 - 2502 lb/day)
AERATION TANK LOAD	0.48 - 0.72 kg/cu m (29.7 - 44.5 lb/1000 cu ft)

SAMPLE COLLECTION AND ANALYSIS

SAMPLE COLLECTION

PLANT INFLUENT - The plant influent samples were collected every two hours from the distribution box between the mixing tanks and then composited into a 24-hour sample for analysis. The sample point is shown as S-1 on Figure 1.

PRIMARY EFFLUENT - Primary effluent samples were collected every two hours and composited into a 24-hour sample for analysis. The sample points are shown as S-2 on Figure 1.

MIXED LIQUOR - Mixed liquor samples for the settlometer and centrifuge tests were collected every six hours from each aeration tank and from the distribution box following the aeration tanks. Both centrifuge and gravimetric tests were run on the samples taken at 9:00 AM. The samples from the aeration tanks were collected from the overflow of each tank, S-3 on Figure 1, and from the distribution box, S-4 on Figure 1.

FINAL EFFLUENT - Final effluent samples were collected every two hours from the Parshall Flume, S-5 on Figure 1, and composited into a 24-hour sample for analysis.

RETURN SLUDGE - Samples for the centrifuge tests and once-per-day gravimetric analysis were collected every six hours from each secondary clarifier draft tube and a combined sample was collected from the entrance to the well ahead of the aeration tanks. The sample points are shown as S-6 on Figure 1.

PRIMARY SLUDGE - A sample was taken once per day for gravimetric analysis.

AEROBIC DIGESTER MIXED LIQUOR - A sample was taken once per day for gravimetric analysis.

ANALYSIS

The above samples were analyzed by Fiberglas personnel in accordance with procedures detailed in Standard Methods for the Examination of Water and Wastewater, Thirteenth Edition.

All reported plant performance data, with the exception of the analyses listed below, are based on the data supplied to Waste Treatment Branch, NFIC-C, personnel by Fiberglas employees.

Aliquots of raw, primary, and final effluent composite samples were filtered through 0.45 micron membrane filters daily. The filtrate and an aliquot of the unfiltered composite were preserved with 1 ml/liter concentrated sulfuric acid and mailed to the NFIC-C Laboratory for nitrogen and phosphorus analyses.

OPERATIONAL CONTROL METHODS

The operational control test procedures described below were demonstrated to OCF personnel by the NFIC-C Waste Treatment Branch during the technical support project. The procedures are taken from the "Operation Control Methods For The Activated Sludge Process", Pamphlet II, which are available upon written request.

This test series enabled plant personnel to determine sludge quality, process status, required chemical additions, and effluent quality during each 24-hour cycle. The results were then used to calculate process demands and operational control requirements and to dictate operational control adjustments.

The tests used for control were:

1. Settlometer

   A settling test in which the mixed liquor sludge interface level (settled sludge volume - SSV) was recorded (in cc/l) at 5-minute intervals for the first 30 minutes and at 10-minute intervals for the next 30 minutes. Two settlometer tests were run at each test period; one on a composite of mixed liquor from each aeration tank, the second on a sample of the chemically treated mixed liquor drawn from the distribution box just ahead of the secondary clarifiers.

2. Centrifuge Test

   A 15-minute centrifuge spin, at approximately 2000 RPM, of the aeration tank mixed liquor and return sludge samples permitted a quick

determination of the suspended solids concentrations. Centrifuge test results were also used to determine solids distribution ratios, check flow measurements, and evaluate other process relationships.

3. Depth of Blanket

Depth of clarifier sludge blanket interface below the surface of the secondary clarifier was used to determine the amount of solids in the secondary clarifier, the solids balance, and the sludge wasting requirements.

4. D.O. Test

The dissolved oxygen concentration of the mixed liquor was measured every six hours to determine aeration requirements.

5. Turbidity Test

Turbidity of the final effluent, as determined by the use of a standard photoelectric type turbidimeter, was used to rapidly determine the effect of process changes on effluent quality; this eliminated having to wait for the results of conventional monitoring-type tests.

6. Jar Test

One liter samples of mixed liquor were dosed with varying quantities of polymer solution taken from the secondary coagulant aid tank and/or a 1/50 solution of 42% ferric chloride. The samples were then stirred for 1 minute at full rpm under a jar test stirring apparatus, stilled, and allowed to settle. Settling rates and supernatant clarity were then observed. It was found that a 5-minute reading of about 600 cc/l was optimum. Observing the type and required dosage of coagulant aid, polymer or ferric chloride, that gave the best supernatant clarity and optimum settling enabled the operator to determine the required plant dosage from Tables D-1 and D-2.

This full series of tests was run daily at 3:00 AM, 9:00 AM, 3:00 PM, and 9:00 PM. Jar tests were run a minimum of once per day. As samples for testing were collected, physical observations of process features such as sludge

color, amount of foam on the aeration tank surface, presence of "clumping" or straggler floc in the secondary clarifiers, etc. were noted by the operators. Flow meter readings were recorded and used in calculating process demands.

The results of the settlometer and centrifuge tests were used to determine settled sludge concentration (SSC). The SSC curve, which defines sludge quality, is calculated from the settled sludge volume (SSV) and the concentration (in percent) of the mixed liquor leaving the aeration tank (ATC) expressed as:

$$SSC = (1000 \times ATC) / (SSV)$$

Illustrative settling curves (SSV) and concentration curves (SSC) are shown in Figure B-1. The curve labeled "Fast" illustrates a sludge characterized by rapid settling and compaction, the curve labeled "Normal" illustrates a normal settling and compacting sludge, while the curve labeled "Slow" represents a slowly settling sludge with almost no compaction.

Trend Chart plots of the process parameters (SSC, SSV, Final Effluent Turbidity) were plotted on two-cycle, semi-log paper at the conclusion of each full test series. An illustration of the SSV, SSC and Effluent Turbidity trend charts appears in Figures B-2, B-3, and B-4. In addition, a wall chart was maintained by plotting Final Effluent Turbidity, Depth of Blanket, and values of Final Effluent BOD 5, COD and Suspended Solids. By referring to these charts the operator could see the relative response of the process factors to the four main control adjustments, return sludge flow, waste sludge flow, chemical dosage, and aeration intensity.

At the end of each day the individual test data were averaged for the day and values for the parameters listed in Table C-4 were determined. Three of the parameters, XSU/day, CSDT, and ATC x ADT were also plotted on semi-logarithmic paper for use as trend charts to aid in judging process response and performance.

Return sludge flows were determined on the basis of process demands, i. e., after each test series the operator

would insert the current values of the ATC, RSC, SSC60, and CSF into the clarifier sludge flow demand formula where clarifier sludge flow (CSF) equals return sludge flow (RSF) plus waste sludge flow (XSF):

$$CSFD = CSF \times (RSC - ATC) / (SSC60 - ATC)$$

It should be noted that when the excess waste sludge flow (XSF) was zero, or minimal compared to the return sludge flow (RSF), RSF and RSFD were substituted for CSF and CSFD to yield:

$$RSFD = RSF \times (RSC - ATC) / (SSC60 - ATC)$$

During most of the project, excess sludge wasting rates were targeted to maintain an approximate sludge age of 15 days. Sludge age is calculated from the formula:

$$AGE = TSU / (XSU/DAY)$$

Table D-3 facilitates rapid conversion of desired waste sludge units to excess waste sludge flow.

In order to accomplish the appropriate chemical addition to the mixed liquor, the following technique was used throughout the project. Polymer additions were made as determined from jar tests until the one available 946 liter (250 gallon) tank was emptied. At that time ferric chloride was added for a minimum of two hours while a new batch of polymer solution was prepared and mixed. Dosage requirements for the newly mixed polymer solution were then determined by jar tests before switching back from iron to polymer feed. At no time did any combination of ferric chloride and polymer give better results than either one separately.

The plant operators found the test series to be both convenient and effective and adopted them as standard operating procedures.

WASTE CHARACTERISTICS

Significant characteristics of the plant influent and aeration tank influent waste streams are described below, and OCF has supplied the additional information presented in Appendix G. A complete tabulation of flow, BOD 5, COD, suspended solids, nitrogen, and phosphorus appears

in Tables C-1, C-5, and C-6. Probability plots of loading and BOD 5 to COD ratios are in Figures E-1 - E-5.

FLOW

Flow for the duration of the project averaged 2373 cu m/day (0.6269 mgd) as shown in Table C-1. The maximum recorded daily flow was 2716 cu m/day (0.7175 mgd) and the minimum was 1687 cu m/day (0.4457 mgd).

pH

pH of the raw flow fluctuated dramatically at times. Generally, the flow was slightly acidic requiring caustic addition to increase the pH to the 7 - 8 range. Batch dumps from production areas varied from extremely acidic to highly alkaline. The raw waste pH occasionally was as low as 3 or as high as 11.5, requiring a caustic or acidic addition to neutralize the flow.

BOD 5

Raw BOD 5 averaged 394 mg/l for the project duration and primary effluent BOD 5 averaged 326 mg/l. It was found that the "deoxygenation constant", k, for the carbonaceous phase of the BOD curve was generally less than 0.15, indicating an uptake slower than that for "domestic" sewage.

The BOD constants were evaluated by the Moore "Moments Method", Daily Difference Method, and the Thomas Graphical Approximation.

COD

Raw COD averaged 1457 mg/l for the project duration and primary effluent COD averaged 779 mg/l. The use of COD analyses was stressed as an operational tool for rapid evaluation of "batch" dumps.

COD : BOD 5 RATIO

The daily composite samples' COD to BOD 5 ratio was calculated, plotted on probability paper and averaged. Standard deviations and standard errors of the means were determined.

The following data are the results of the calculations:

PARAMETER	MEAN RATIO	STANDARD DEVIATION	STANDARD ERROR OF MEAN
Raw COD / Raw BOD 5	3.900	1.1852	+-0.12
Pri Effl COD / Pri Effl BOD 5	2.566	0.7736	+-0.07
Fin Effl COD / Fin Effl BOD 5	14.02	7.0756	+-0.72

This permitted using the ratios to obtain a reasonable estimate of the BOD 5 value from the COD analyses. The following example illustrates this.

PRIMARY EFFLUENT COD (mg/l)	MEAN RATIO	CALCULATED BOD 5 (mg/l)
800	2.566	312 +-17 (95% Conf.)

By first running the COD on plant samples, the calculated BOD 5 would then give reasonable assurance of setting up the correct dilutions for BOD 5 analyses. The COD to BOD 5 ratio should be checked periodically.

SUSPENDED SOLIDS

Raw Total Suspended Solids for the project averaged 469 mg/l and primary effluent averaged 133 mg/l.

NUTRIENTS

The BOD : nitrogen : phosphorus ratio of the primary effluent averaged 100 : 3.4 : 0.14 for the final 77 days of the project. (This ratio is for primary effluent before it was combined with return sludge.)

Nutrient additions were not made for the first 12 days of the project. For the remainder of the project nutrients were added to the return sludge in an attempt to obtain a ratio of 100 : 5 : 1.

PLANT PERFORMANCE

Complete plant performance data for the project duration, March 1, 1973, to June 3, 1973, have been plotted and tabularized. (Figures 2-21, Tables C-1 - C-6) The data have been divided into nine periods and discussion of plant performance will follow this breakdown throughout.

Period	No. of Days	Dates	Character
1	13	3-1 to 3-13	Project Start-Up
2	5	3-14 to 3-18	Overload - Upset
3	36	3-19 to 4-23	Stable Operation
4	4	4-24 to 4-27	Overload - Degraded
5	25	4-28 to 5-22	Stable Operation
6	4	5-23 to 5-26	Overload - Degraded
7	8	5-27 to 6-3	Project Conclusion
8	77	3-19 to 6-3	Final 77 Days
9	73	3-19 to 6-3 Excluding 4-25,26 & 5-25,26	73 of Final 77 Days Highlights Effect of Overload

The discussion of the project will center on the Figures within the body of the report. Note that in the Figures, the first seven periods have been delineated and numbered, and appropriate average values have been posted for each period. On all Figures the appropriate metric scale is shown on the left side. On many Figures, Figure 8 for example, the former standard English units are shown on the right side. The tabularized data in the appendices are broken into the same periods with the addition of <8> and <9>. Period <9> is included to show that when the problem of handling the batch dumps is resolved, plant personnel should be satisfied with nothing less than the effluent quality shown in Period <9>, Table C-5 and, in fact, they should continually strive to improve on it.

SLUDGE QUALITY

The request for technical support cited a bulking problem at the treatment facility. Waste Treatment Group Personnel were, in fact, confronted with a "slow" settling sludge at the beginning of the project. Figure 2 is a plot of the daily average 5- and 60-minute settled sludge volume

(Comp. SSV), based on a composite sample of mixed liquor to which neither polymer or ferric chloride had been added. For Period <1> , Comp. SSV 5 averaged 984 cc/l and Comp. SSV60 averaged 828 cc/l. Figure 3 shows mixed liquor concentration (ATC), calculated 60-minute settled sludge concentration (Comp. SSC 60), and the return sludge concentration (RSC), based on the composite sample. Note that for Period <1> the average ATC of 9.35 % could concentrate to only 11.43 % in one hour (Comp. SSC 60), but that the average RSC was 17.03 %.

Figure 4 shows the SSV 5 and SSV 60 for the mixed liquor as it entered the secondary clarifiers with polymer or iron addition. Figure 5 compares the dosed mixed liquor's ability to concentrate with the return sludge concentration. Note that the mixed liquor of 9.35 % concentrated to a Dosed SSC 60 of 15.83 % for Period <1>. The RSC of 17.03 % then indicates that the sludge remained in the secondary clarifiers somewhat more than one hour. (1.5 hour from Table C-3)

Polymer solution dosage for Period <1> averaged 1225 ml/min, Figure 6.

The "overload" Periods <2> and <4>, resulting from significant batch dumps, display similar effects on sludge settling and concentration characteristics. Figure 5 shows the effect more dramatically. Note the "sag" in the Dosed SSC 60 curve; the ability to concentrate was hindered by the overload, especially during Period <2>. Figure 6 shows that even a marked increase in polymer dosage could not concentrate the sludge properly.

The "stable" operation Periods <3> and <5> also show similar characteristics. Figure 2 illustrates the improved settleability of the composite mixed liquor, displaying the following:

PERIOD	SSV 5	SSV 60
1	984	828
3	913	464
5	938	513

Figure 6 shows that decreasing polymer and iron additions were required to enhance the settling characteristic as sludge quality improved.

The significance of the WCR now becomes apparent (Figure 7). WCR is the gravimetric concentration of the

mixed liquor solids, MLTSS, divided by the ATC. This ratio is most certainly an indication of sludge quality and age. From Tables C-4 and C-5 note the following:

PERIOD	1	3	5
Avg MLTSS (Mg/L)	2738	3204	3553
Avg ATC (%)	9.35	6.68	6.06
Avg WCR	294	499	615

where Avg WCR has been calculated from daily WCR values, i.e. paired data, not Avg MLTSS/Avg ATC. WCR values should be closely monitored. It is not absolutely necessary to gravimetrically determine MLTSS daily during stable operation periods; during critical periods daily determination is desirable.

The WCR value may also be used to convert RSC values to gravimetric concentration if desired using the following equation:

$$RSTSS = WCR \times RSC$$

As the mixed liquor's concentration by weight increased, its volume percentage decreased. "Young" or "fluffy" sludge will not concentrate as well as the "old" or "dense" sludge. This aids in explaining Period <6>. Figures 4, 5, and 7 reveal that during the overload Periods 2 and 4 (at WCR of 373 and 456) settling and thus the ability to concentrate was impeded by the overload. During the overload Period <6> (at WCR of 840) the settling rate became more rapid and the ability to concentrate increased. Figure 7 displays this difference in sludge quality. This reveals the strong relationship between WCR and sludge quality. As WCR increased there was a lessening adverse effect of the shock loadings - performance improved as sludge quality improved. It is important to emphasize that WCR can be controlled by waste sludge flow control. Decreased wasting generally increases WCR, increased wasting usually decreases WCR. During Period <6>, WCR had increased to such a level that settling rate increased during the overload condition. This indicates that a WCR value of about 800 is probably the upper limit for this plant.

An additional important feature of the concentration curve must be noted. It was previously stated that "return sludge flows were determined on the basis of process demands". The plant was operated on the "60 minute demand" for the project duration. The concentration curve then displays one phase of plant performance. Under 60-minute

control, ideally the plots of RSC should nearly coincide with SSC 60. Figure 5, the concentration curve of the dosed mixed liquor actually flowing into the secondary clarifiers, shows how well 60 minute control was maintained. On many occasions the calculated demand was less than the minimum attainable return sludge flow, resulting in RSC falling below SSC 60. This fact, coupled with the conservative clarifier overflow rate, strongly suggests that plant performance might be improved by operating with only two of the three secondary clarifiers on line.

Sludge quality cannot be overemphasized. The operator must keep the following in mind in order to accomplish consistent high quality final effluent: DON'T LOOK AT ISOLATED PARAMETERS OR SYMPTOMS OF THE ACTIVATED SLUDGE PROCESS. STUDY THE INTERRELATIONSHIPS OF THE PARAMETERS TO SEEK OUT SOLUTIONS TO OPERATIONAL PROBLEMS - LOOK AT PROCESS DEMANDS AND PROCESS RESPONSE TO CONTROL ADJUSTMENTS.

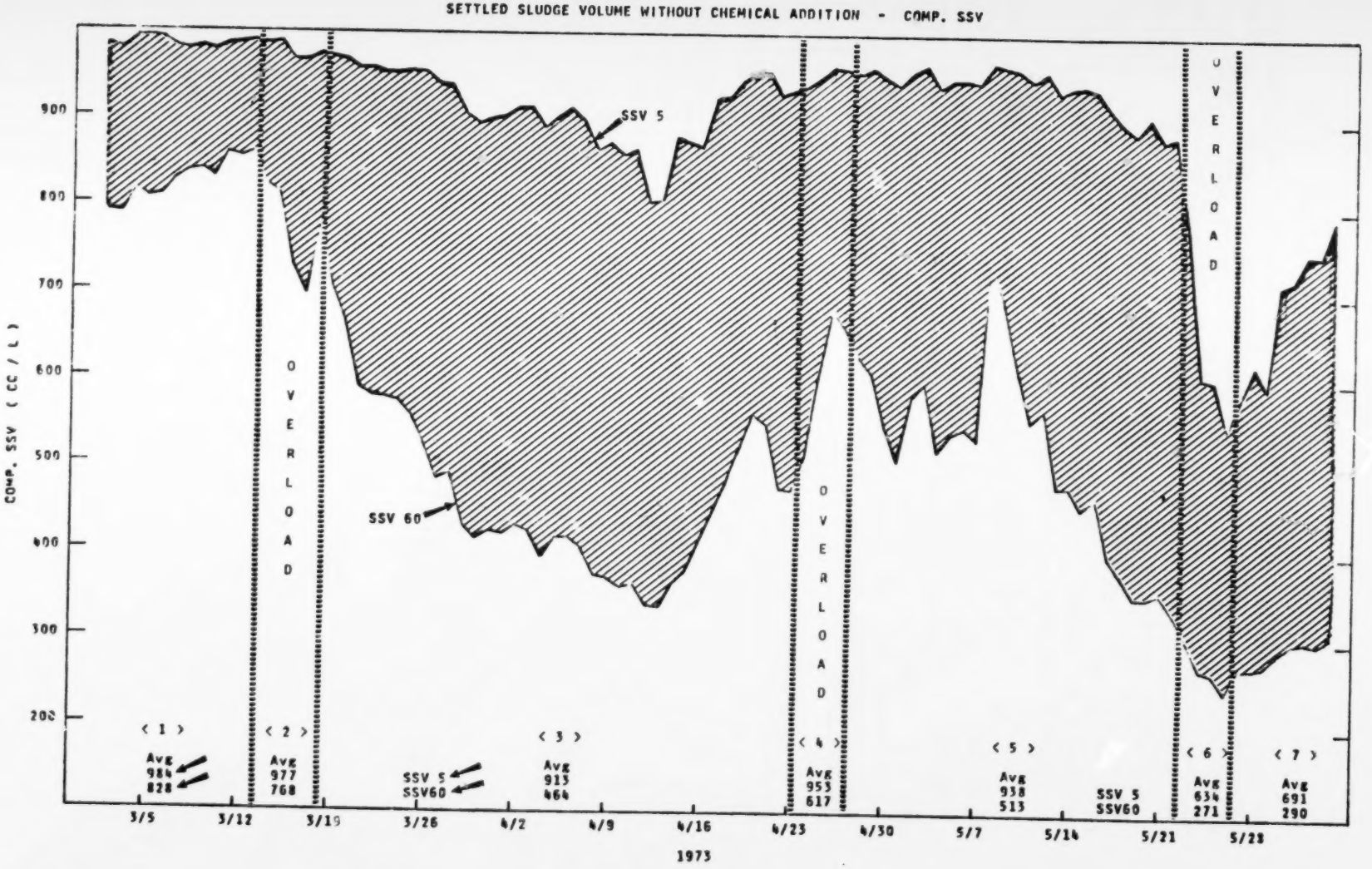

SETTLED SLUDGE VOLUME WITHOUT CHEMICAL ADDITION - COMP. SSV
COMP. SSV (CC / L)
900
800
700
600
500
400
300
200
SSV 5
SSV 60
OVERLOAD
OVERLOAD
OVERLOAD
< 1 >
Avg
984
828
< 2 >
Avg
977
768
SSV 5
SSV60
< 3 >
Avg
913
464
< 4 >
Avg
953
617
< 5 >
Avg
938
513
SSV 5
SSV60
< 6 >
Avg
634
271
< 7 >
Avg
691
290
3/5
3/12
3/19
3/26
4/2
4/9
4/16
4/23
4/30
5/7
5/14
5/21
5/28
1973

FIGURE 2

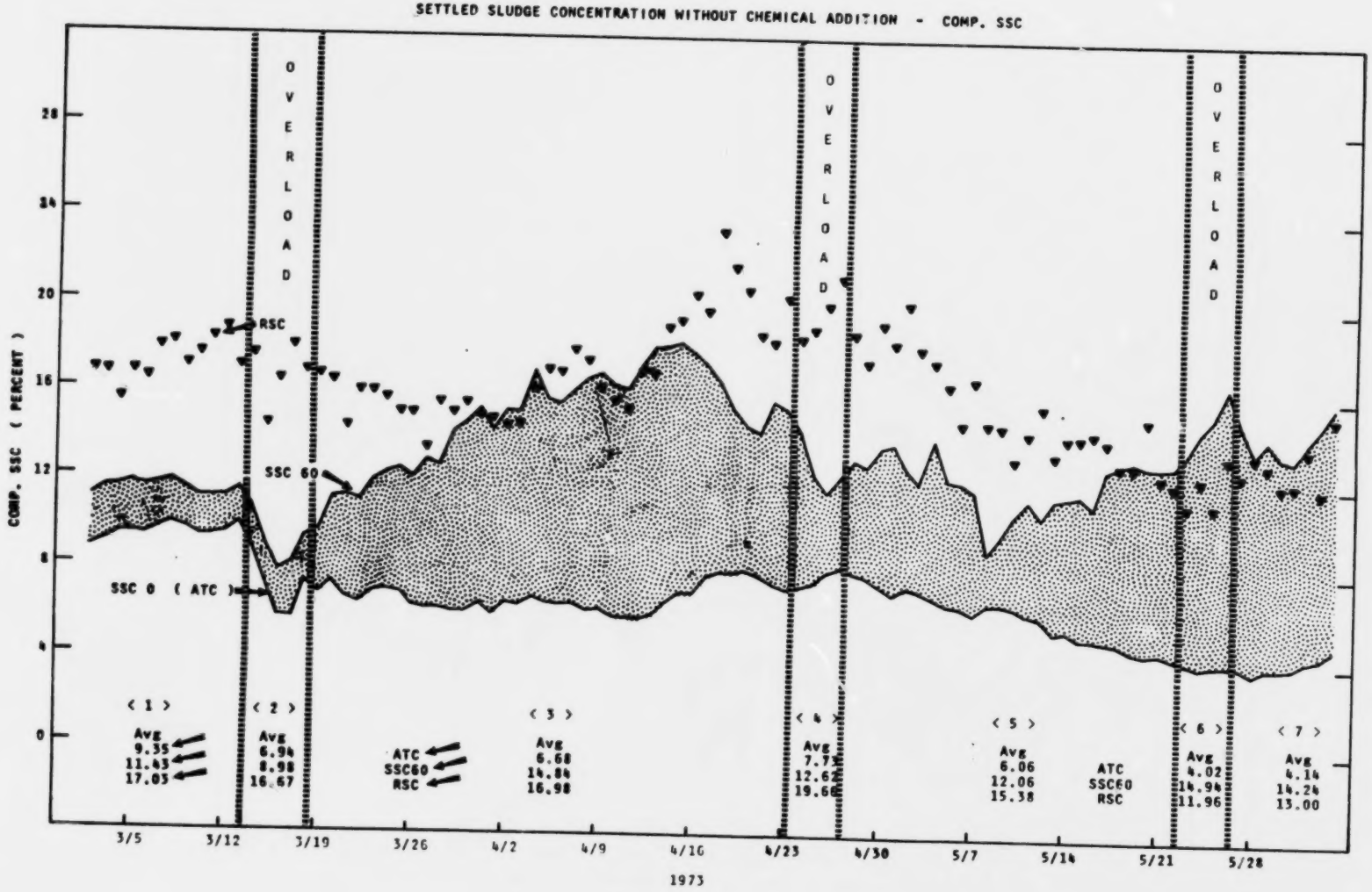

SETTLED SLUDGE CONCENTRATION WITHOUT CHEMICAL ADDITION - COMP. SSC
COMP. SSC (PERCENT)
OVERLOAD
OVERLOAD
OVERLOAD
RSC
SSC 60
SSC 0 (ATC)
< 1 >
Avg
9.35
11.43
17.05
< 2 >
Avg
6.94
8.98
16.67
ATC
SSC60
RSC
< 3 >
Avg
6.68
14.84
16.98
< 4 >
Avg
7.73
12.62
19.66
< 5 >
Avg
6.06
12.06
15.38
ATC
SSC60
RSC
< 6 >
Avg
4.02
14.94
11.96
< 7 >
Avg
4.14
14.24
13.00
3/5
3/12
3/19
3/26
4/2
4/9
4/16
4/23
4/30
5/7
5/14
5/21
5/28
1973

FIGURE 3

SETTLED SLUDGE VOLUME WITH CHEMICAL ADDITION, POLYMER OR FERRIC CHLORIDE - DOSED SSV

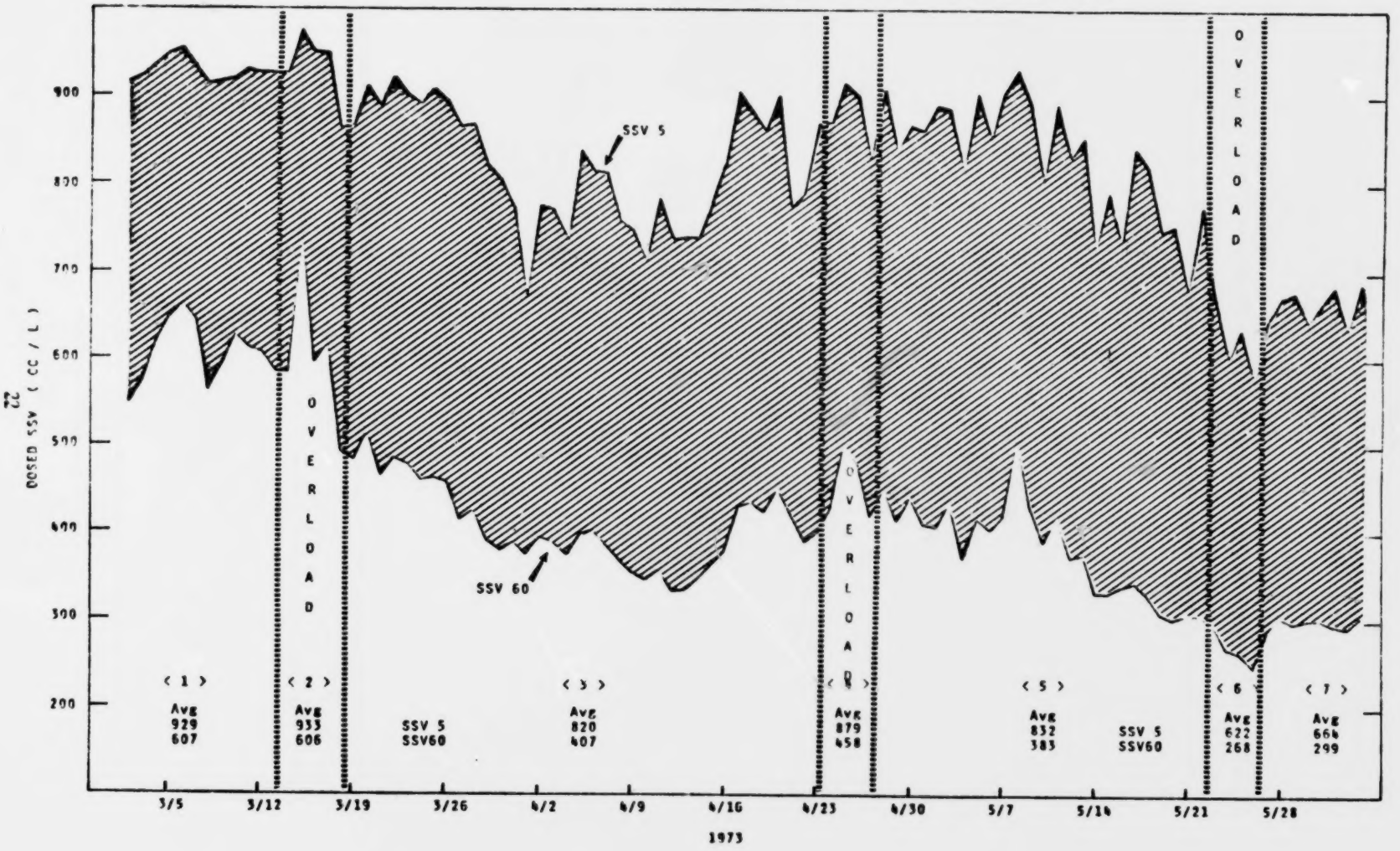
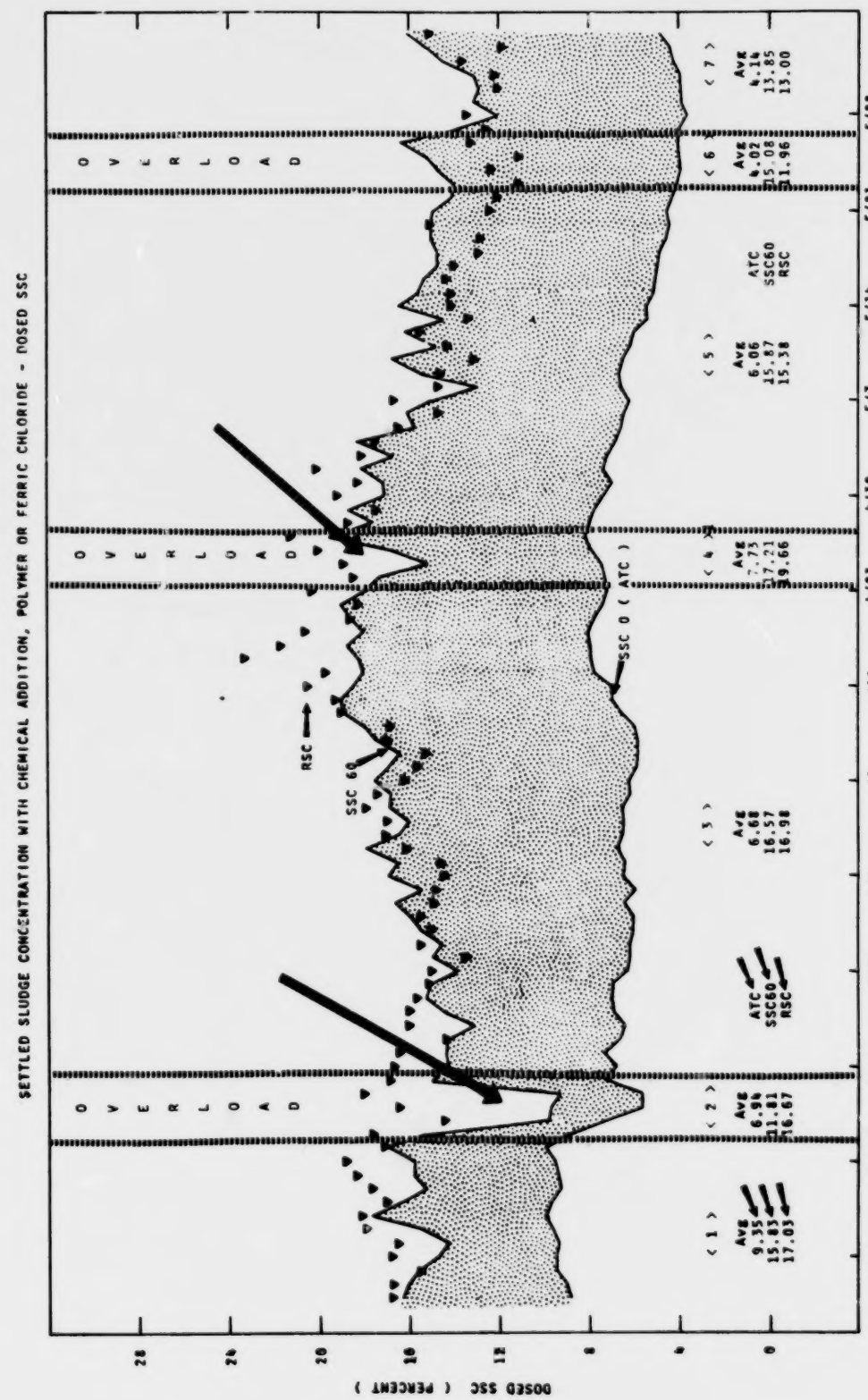


FIGURE 4

FIGURE 5


SETTLED SLUDGE CONCENTRATION WITH CHEMICAL ADDITION, POLYMER OR FERRIC CHLORIDE - DOSED SSC
DOSED SSC (PERCENT)
28
24
20
16
12
8
4
0
OVERLOAD
OVERLOAD
OVERLOAD
RSC
SSC 60
SSC 0 (ATC)
< 1 >
Ave
9.35
15.83
17.03
< 2 >
Ave
6.94
11.81
16.67
< 3 >
Ave
6.68
16.57
16.98
< 4 >
Ave
7.73
17.21
19.66
< 5 >
Ave
6.06
15.87
15.38
< 6 >
Ave
4.02
15.08
11.96
< 7 >
Ave
4.14
13.85
13.00
ATC
SSC60
RSC
3/5
3/12
3/19
3/26
4/2
4/9
4/16
4/23
4/30
5/7
5/14
5/21
5/28
1973

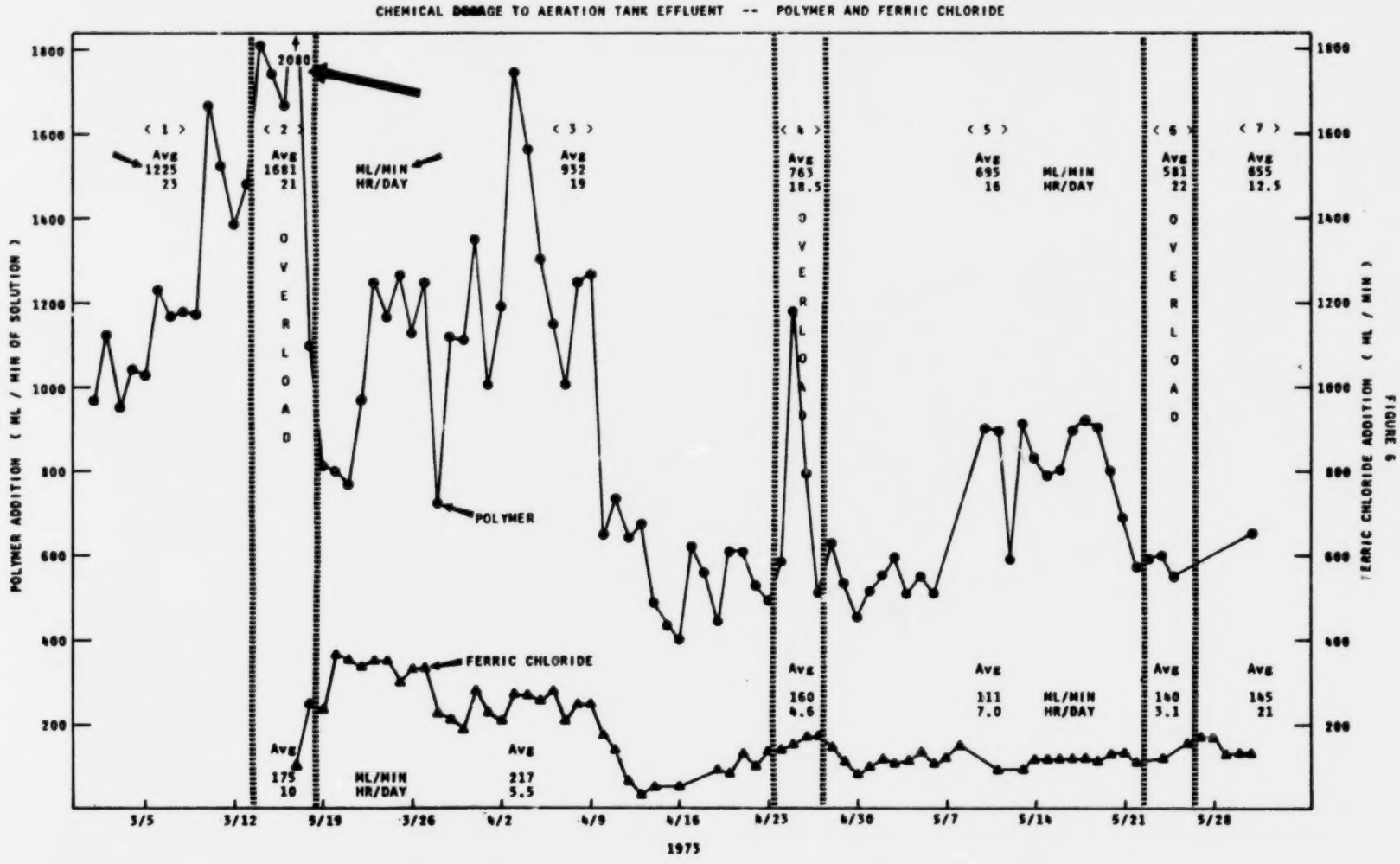
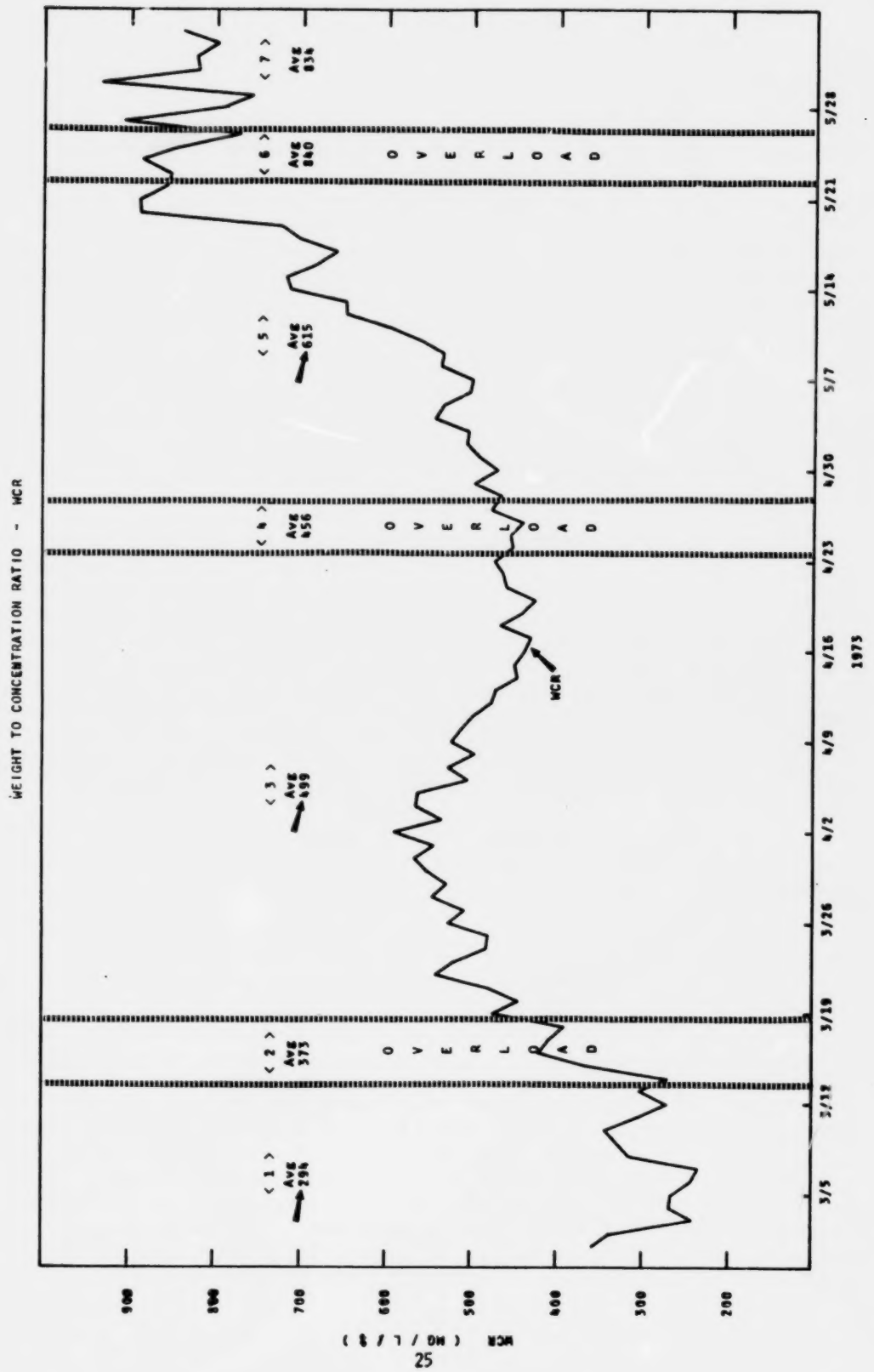

CHEMICAL DOSAGE TO AERATION TANK EFFLUENT -- POLYMER AND FERRIC CHLORIDE
POLYMER ADDITION (ML / MIN OF SOLUTION)
FERRIC CHLORIDE ADDITION (ML / MIN)
1800
1600
1400
1200
1000
800
600
400
200
2080
< 1 >
Avg
1225
23
< 2 >
Avg
1681
21
ML/MIN
HR/DAY
OVERLOAD
< 3 >
Avg
932
19
< 4 >
Avg
763
18.5
OVERLOAD
< 5 >
Avg
695
16
ML/MIN
HR/DAY
< 6 >
Avg
581
22
OVERLOAD
< 7 >
Avg
655
12.5
POLYMER
FERRIC CHLORIDE
Avg
175
10
ML/MIN
HR/DAY
Avg
217
5.5
Avg
160
4.6
Avg
111
7.0
ML/MIN
HR/DAY
Avg
140
3.1
Avg
145
21
3/5
3/12
3/19
3/26
4/2
4/9
4/16
4/23
4/30
5/7
5/14
5/21
5/28
1973

FIGURE 6

FIGURE 7


WEIGHT TO CONCENTRATION RATIO - WCR
WCR (MG / L / %)
900
800
700
600
500
400
300
200
5/5
5/12
5/19
5/26
6/2
6/9
6/16
6/23
6/30
7/7
7/14
7/21
7/28
1973
WCR
< 1 >
Ave 296
< 2 >
Ave 375
< 3 >
Ave 499
< 4 >
Ave 456
< 5 >
Ave 615
< 6 >
Ave 840
< 7 >
Ave 836
O V E R L O A D
O V E R L O A D

LOADING

Although loading to the primary system will be discussed only briefly, this is not intended to minimize the importance of primary sedimentation. Data about loadings and reductions through the primary system appear in Table C-2. The need to optimize primary treatment was confirmed by the concurrent sag in primary reductions and overall treatment efficiency during the overload periods. Primary sludge withdrawal must be controlled diligently to avoid spillover of primary sludge that would needlessly increase the loading to the secondary system.

Figures 8 and 9 respectively display BOD 5 and COD loading in weight per volume to the aeration tanks. They reveal the reasonable correlation between BOD 5 and COD data. Data pertinent to this correlation appear in Figures E-3, E-4, and E-5.

Of more significance is recognition of the need to reduce the magnitude of the "overloads" and to maintain consistent effluent quality during "overload" periods. Periods <2>, <4>, and <6> exceed the design engineer's anticipated loading to the secondary system (Table 2, Tables C-2 - C-3, Figures 8 and 10). Figure 10 displays daily BOD 5 loading and the number of times that the anticipated loading to the plant and the secondary system was exceeded. Figures 11, 12, and 13 show response to the load in terms of dissolved oxygen residual and the oxygen uptake in the aeration tanks and return sludge.

Figure 11 displays the oxygen sag during the overload periods and shows that the D. O. in aeration tank number 3 was much lower than that in tanks 1 and 2.

The magnitude of average BOD 5 loading per volume of aeration tank capacity, 526.4 g/cu m (32.9 lb/1000 cu ft), was less than the "Ten State Standard" suggested level of 640 g/cu m (40 lb/1000 cu ft). The inability to maintain satisfactory D. O. levels in the aeration tanks during overload periods was a limiting factor. The organic character of the waste must also be considered a part of what level of loading can be treated to an acceptable effluent quality. Tables C-3 and C-5 show that the existing facility treated Bod 5 loading of 441.6 g/cu m (27.6 lb/1000 cu ft) to the reasonable effluent quality of 14 mg/l BOD 5 and 15 mg/l Suspended Solids during Period <5>. Treatment accomplished during the overload periods was not satisfactory. It must also be noted that the magnitude of load by itself cannot justify reduced process efficiency.

During Period <2> the magnitude of the "overload" was in fact only BOD 5 loading of 526 g/cu m (32.9 lb/1000 cu ft). Effluent quality during that period was grossly degraded. Improved sludge quality dampened the effect of subsequent overloads.

Figure 13 contains information that helps explain why treatment efficiency suffered during overload periods. The graph of "Unfed Return Sludge Oxygen Uptake" shows the increased oxygen requirement of the return sludge during overload periods. Certainly if "food" remains in the sludge as it is settled in the secondary clarifier, it is not ready to be mixed with more "food" as it is returned to the aeration tanks. Modifications to the air system are needed to improve this situation. These data indicate the need for operators to learn how to shift from "conventional" to "step feed" to "contact stabilization" to satisfy the oxygen demand of the return sludge during high-load operations. However, this also requires that the facility have the appropriate control capability.

Figures 14, 15, and 16 show Depth of Blanket (DOB), clarifier sludge detention time (CSDT), and secondary clarifier overflow rate (OFR). The correlation between CSDT and DOB is evident, i. e. control adjustments that lowered the sludge blanket also reduced CSDT. CSDT during the stable operating Periods <3> and <5> averaged 0.57 and 0.81 hours respectively. These values are lower than the usual optimum range of 0.85 to 1.2 because hydraulic limitations of the three secondary clarifier configuration precluded reducing return sludge flows to meet process demands. Secondary clarifier surface overflow rates were reasonably consistent and certainly conservative. At these overflow rates CSDT and DOB were not influenced appreciably by waste flow rates alone, i. e. blanket thickness did not increase with increased waste flow.

FIGURE 8

AERATION TANK BOD LOAD (LB BOD / DAY / 1000 CU FT)
70
60
50
40
30
20
10
0
AERATION TANK BOD LOAD (G BOD / DAY / CU M)
1250
1000
750
500
250
0
AERATION TANK BOD 5 LOAD
OVERLOAD
OVERLOAD
Range of Anticipated Loading to Aeration Tanks
< 1 >
Ave
390
(24)
< 2 >
Ave
526
(33)
< 3 >
Ave
418
(27)
< 4 >
Ave
804
(56)
< 5 >
Ave
442
(28)
< 6 >
Ave
726
(45)
< 7 >
Ave
525
(33)
3/5
3/12
3/19
3/26
4/2
4/9
4/16
4/23
4/30
5/7
5/14
5/21
5/28
1973

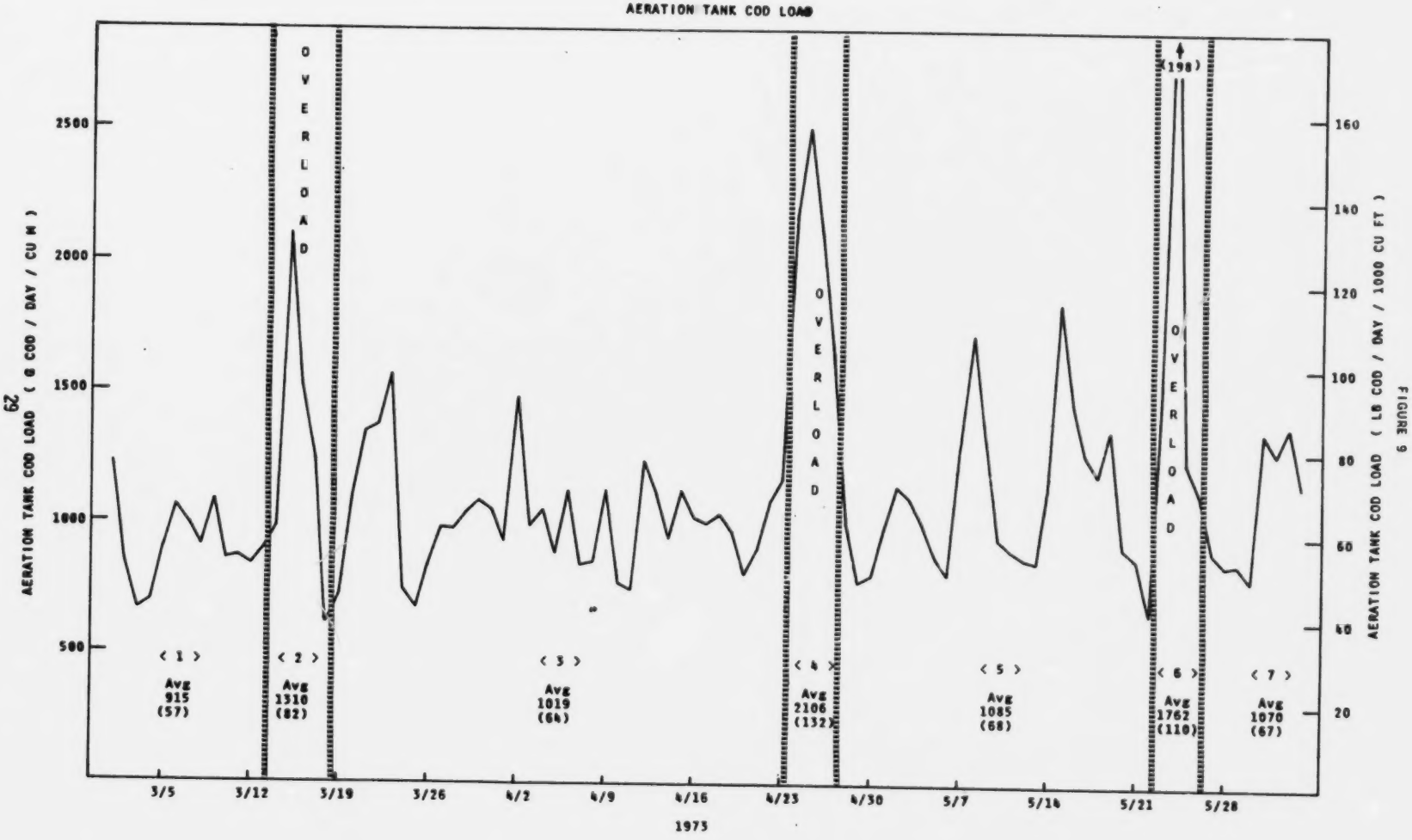

AERATION TANK COD LOAD
AERATION TANK COD LOAD (# COD / DAY / CU M)
AERATION TANK COD LOAD (LB COD / DAY / 1000 CU FT)
2500
2000
1500
1000
500
160
140
120
100
80
60
40
20
OVERLOAD
OVERLOAD
OVERLOAD
(198)
< 1 >
Avg
915
(57)
< 2 >
Avg
1310
(82)
< 3 >
Avg
1019
(64)
< 4 >
Avg
2106
(132)
< 5 >
Avg
1085
(68)
< 6 >
Avg
1762
(110)
< 7 >
Avg
1070
(67)
3/5
3/12
3/19
3/26
4/2
4/9
4/16
4/23
4/30
5/7
5/14
5/21
5/28
1973

FIGURE 9

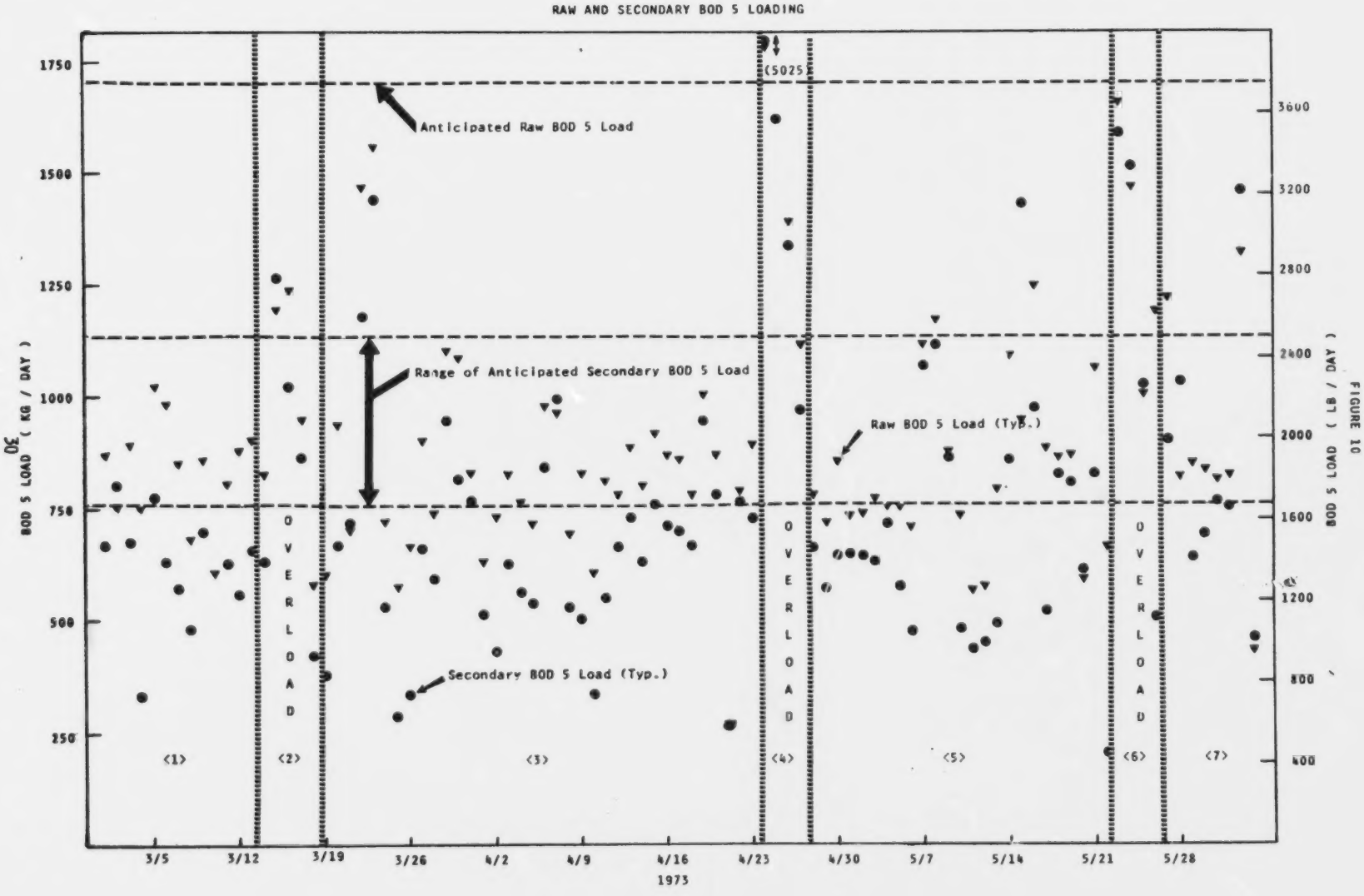

RAW AND SECONDARY BOD 5 LOADING
(5025)
Anticipated Raw BOD 5 Load
Range of Anticipated Secondary BOD 5 Load
Raw BOD 5 Load (Typ.)
Secondary BOD 5 Load (Typ.)
OVERLOAD
OVERLOAD
OVERLOAD
BOD 5 LOAD (KG / DAY)
BOD 5 LOAD (LB / DAY)
1750
1500
1250
1000
750
500
250
3600
3200
2800
2400
2000
1600
1200
800
400
<1>
<2>
<3>
<4>
<5>
<6>
<7>
3/5
3/12
3/19
3/26
4/2
4/9
4/16
4/23
4/30
5/7
5/14
5/21
5/28
1973

FIGURE 10

FIGURE 11

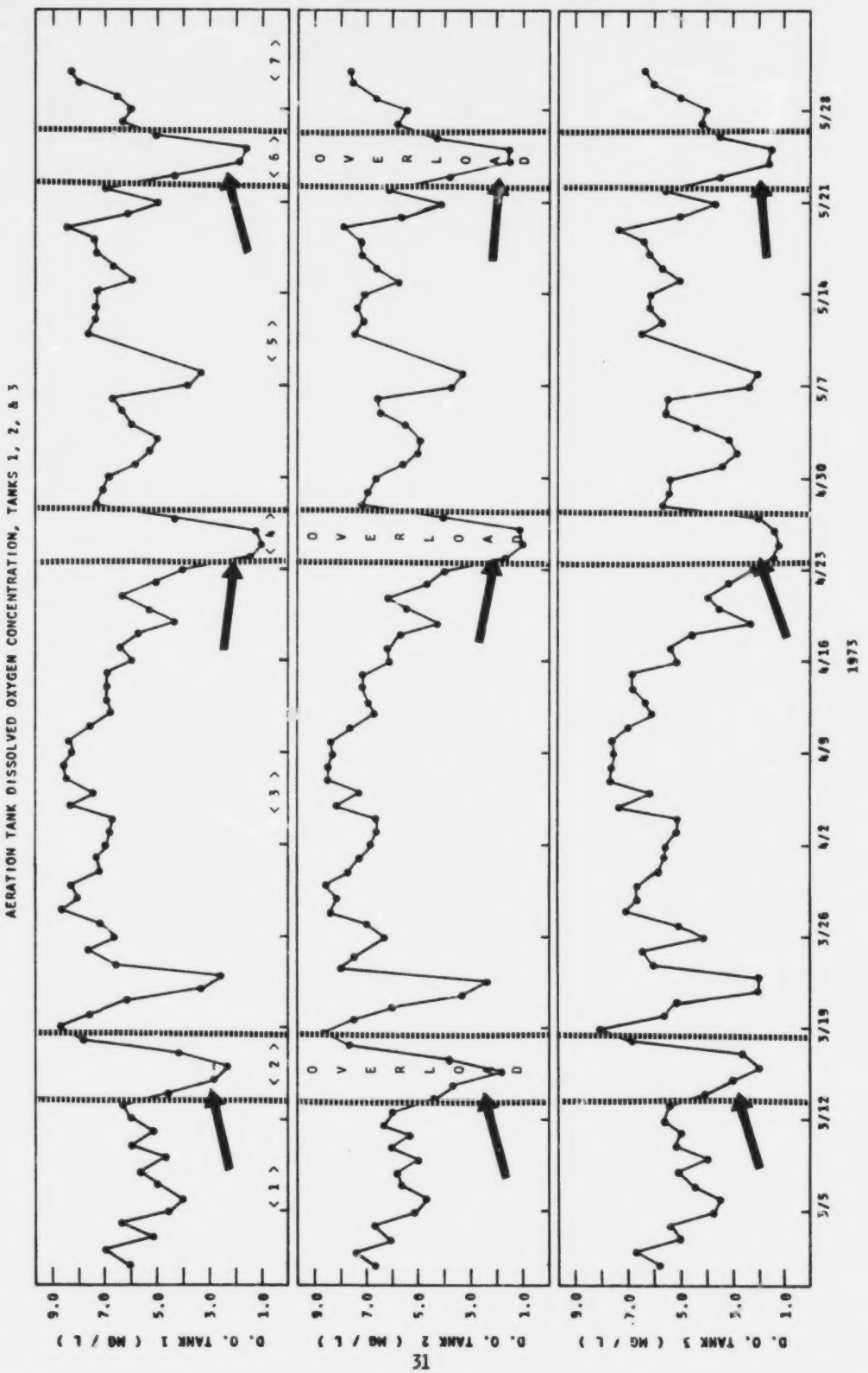
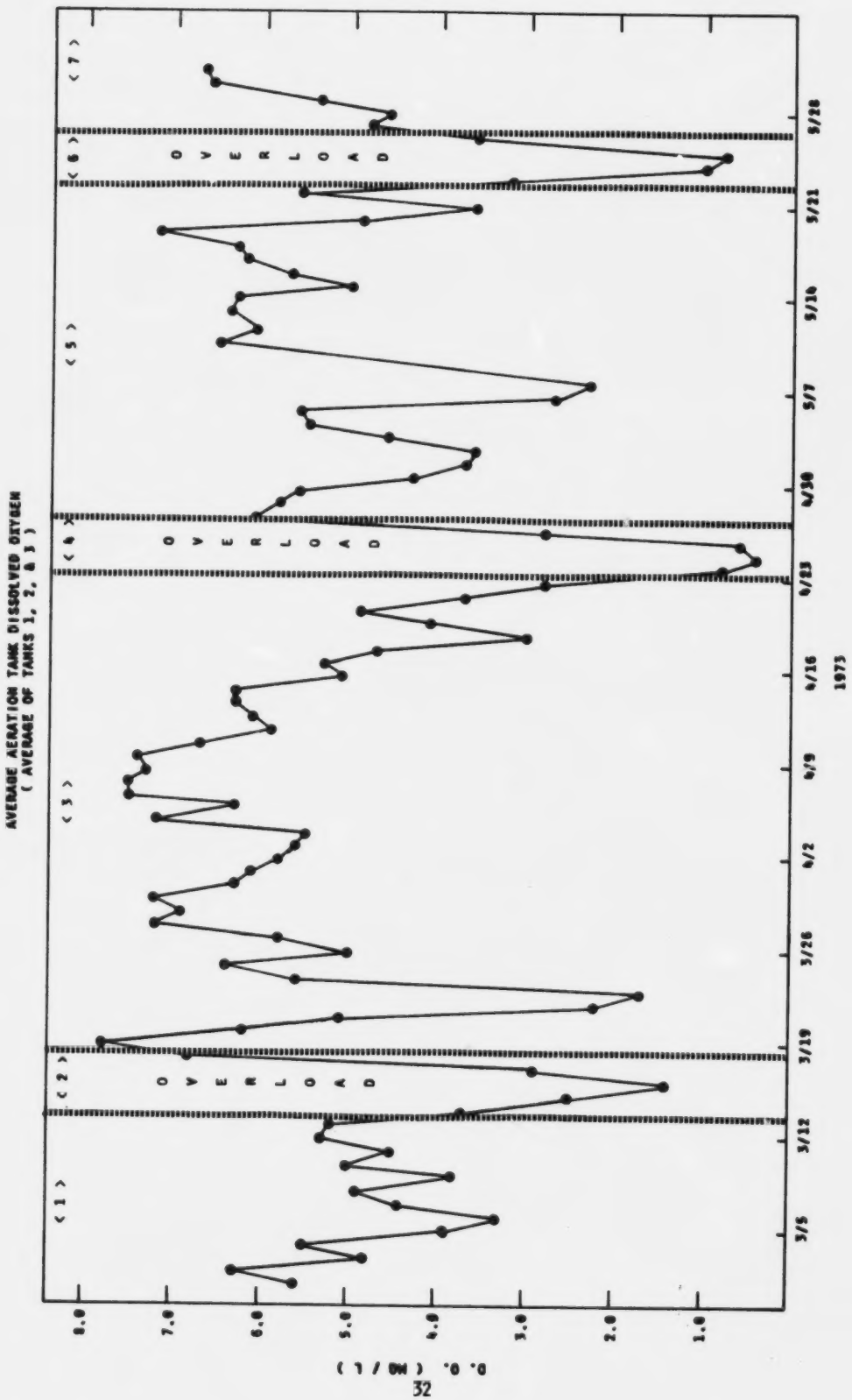

AERATION TANK DISSOLVED OXYGEN CONCENTRATION, TANKS 1, 2, & 3
D. O. TANK 1 (MG / L)
D. O. TANK 2 (MG / L)
D. O. TANK 3 (MG / L)
9.0
7.0
5.0
3.0
1.0
OVERLOAD
<1>
<2>
<3>
<4>
<5>
<6>
<7>
5/5
5/12
5/19
3/26
4/2
4/9
4/16
4/23
4/30
5/7
5/14
5/21
5/28
1973

FIGURE 12


AVERAGE AERATION TANK DISSOLVED OXYGEN
(AVERAGE OF TANKS 1, 2, & 3)
D. O. (MG / L)
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
< 1 >
< 2 >
< 3 >
< 4 >
< 5 >
< 6 >
< 7 >
OVERLOAD
OVERLOAD
3/5
3/12
3/19
3/26
4/2
4/9
4/16
4/23
4/30
5/7
5/14
5/21
5/28
1973

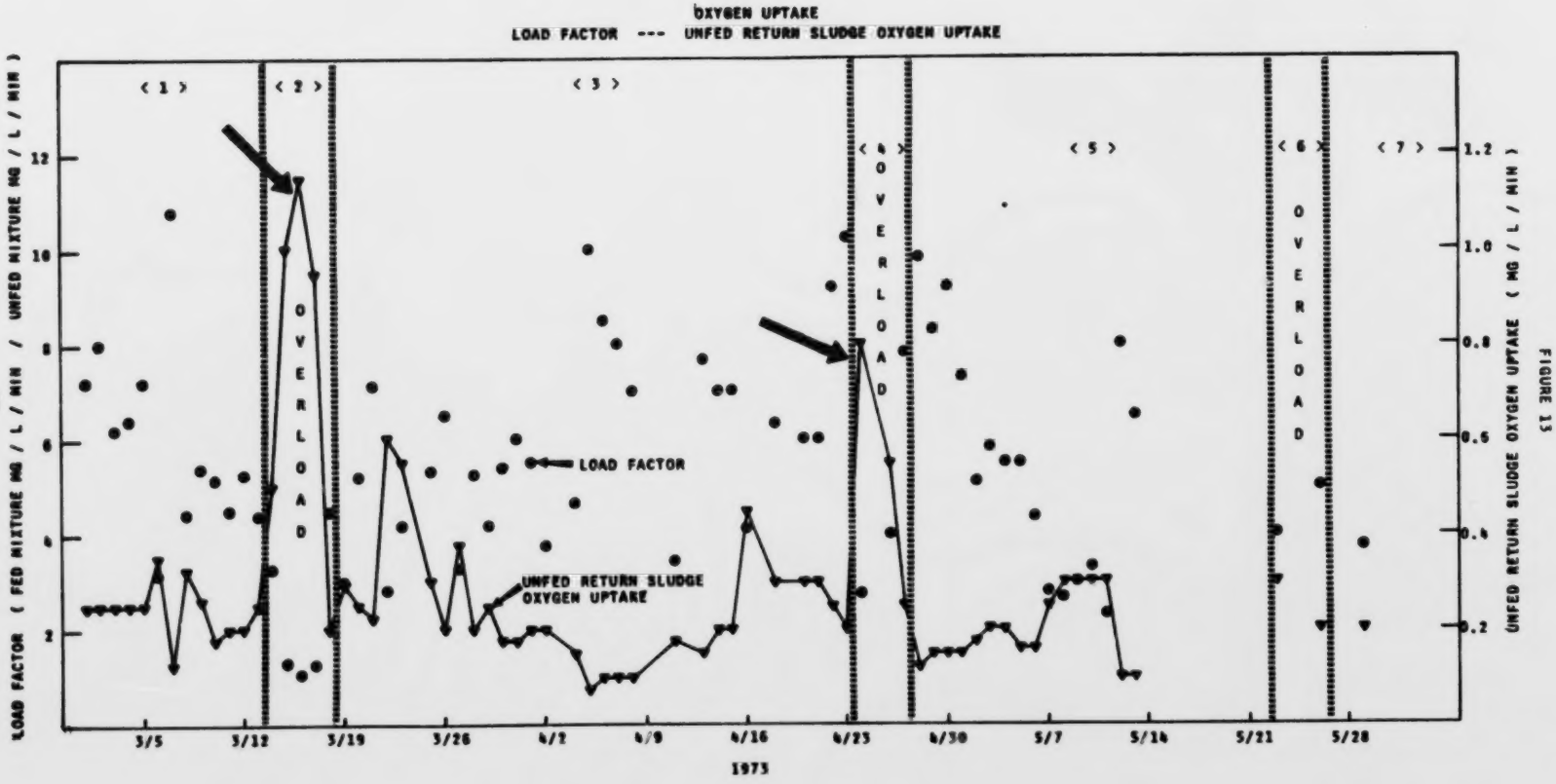

OXYGEN UPTAKE
LOAD FACTOR --- UNFED RETURN SLUDGE OXYGEN UPTAKE
LOAD FACTOR (FED MIXTURE MG / L / MIN / UNFED MIXTURE MG / L / MIN)
UNFED RETURN SLUDGE OXYGEN UPTAKE (MG / L / MIN)
< 1 >
< 2 >
< 3 >
< 4 >
< 5 >
< 6 >
< 7 >
OVERLOAD
OVERLOAD
OVERLOAD
LOAD FACTOR
UNFED RETURN SLUDGE OXYGEN UPTAKE
12
10
8
6
4
2
1.2
1.0
0.8
0.6
0.4
0.2
3/5
3/12
3/19
3/26
4/2
4/9
4/16
4/23
4/30
5/7
5/14
5/21
5/28
1973

FIGURE 13

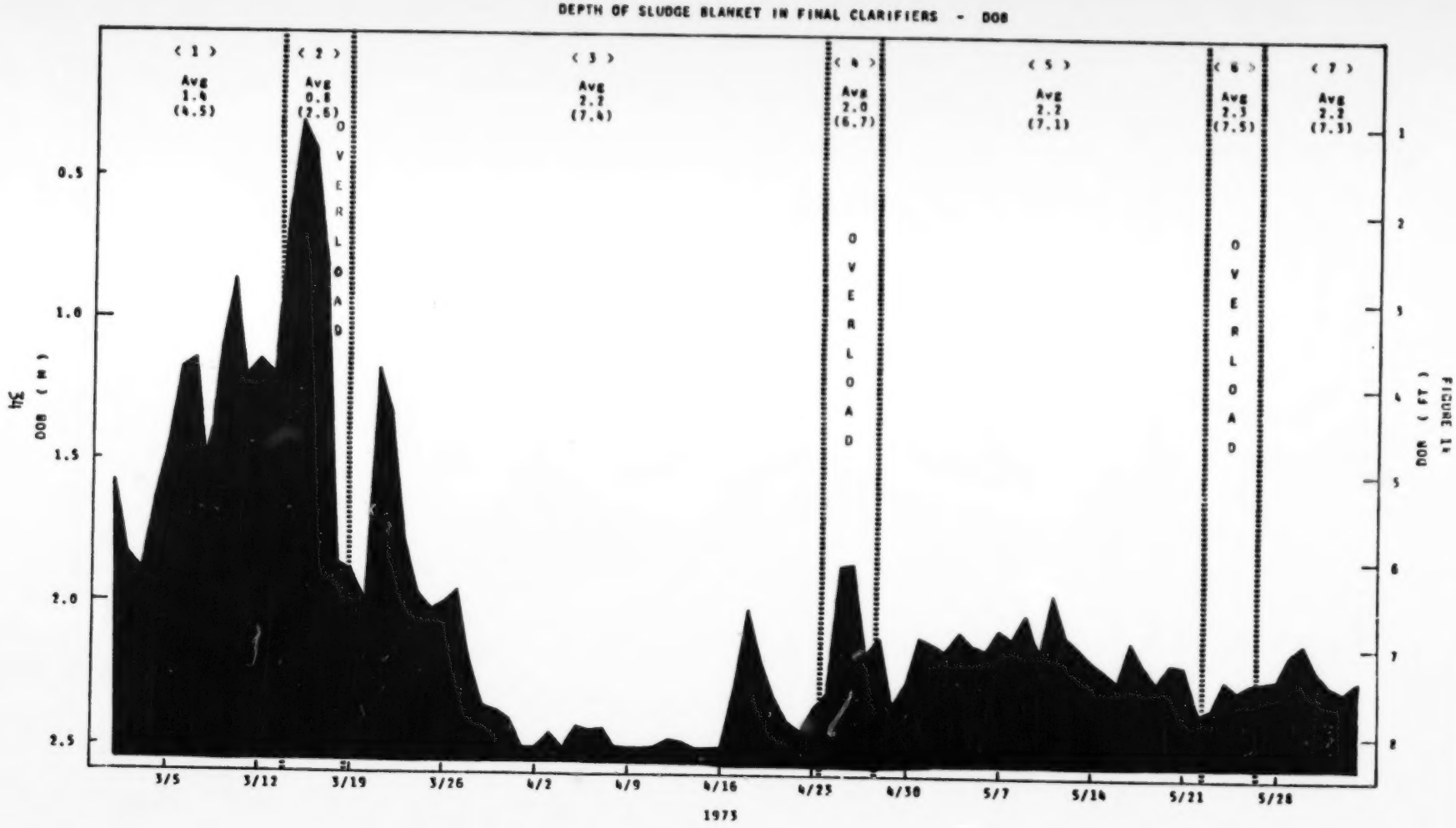
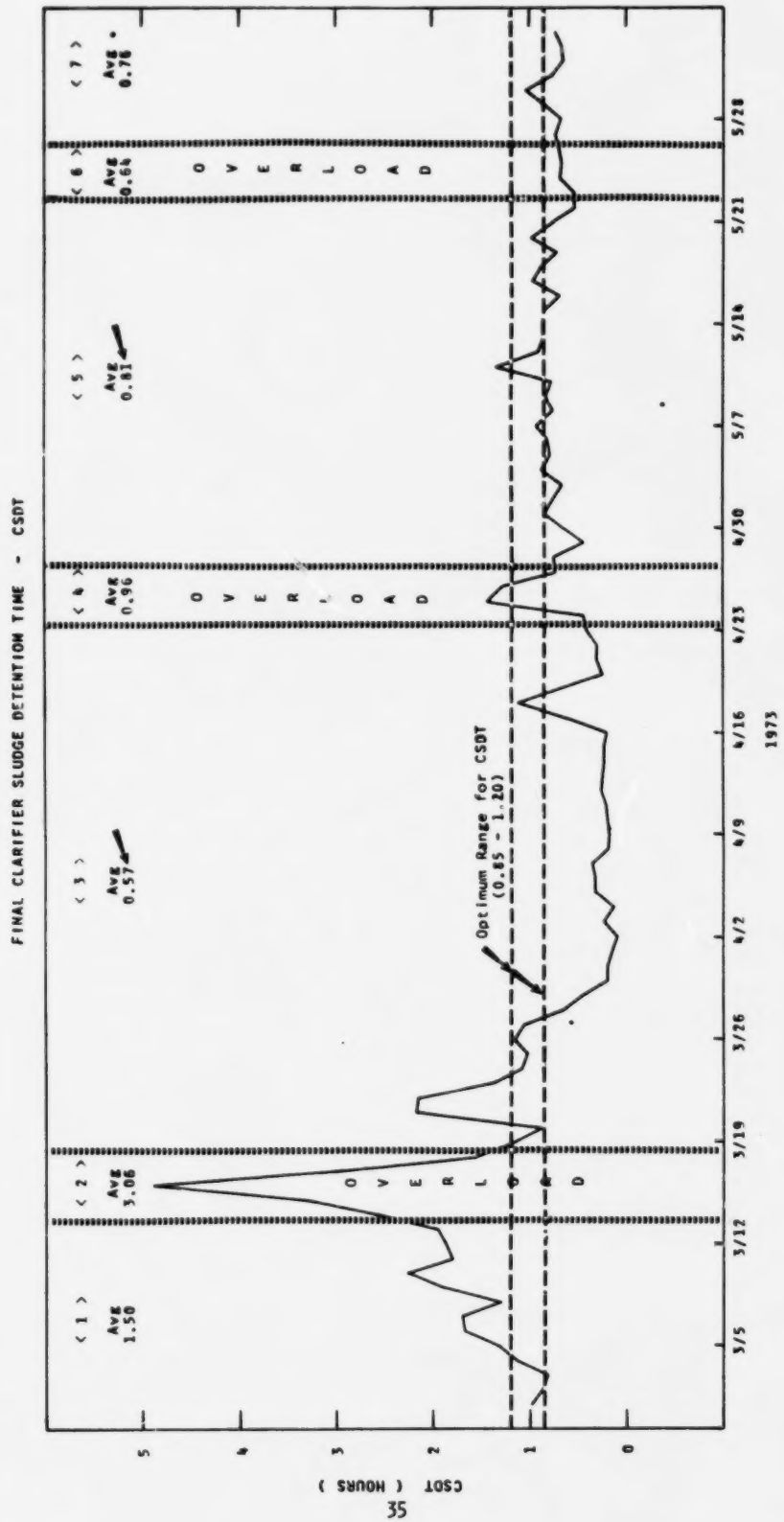

DEPTH OF SLUDGE BLANKET IN FINAL CLARIFIERS - DOB
(1)
Avg
1.4
(4.5)
(2)
Avg
0.8
(2.6)
OVERLOAD
(3)
Avg
2.2
(7.4)
(4)
Avg
2.0
(6.7)
OVERLOAD
(5)
Avg
2.2
(7.1)
(6)
Avg
2.3
(7.5)
OVERLOAD
(7)
Avg
2.2
(7.3)
DOB (M)
DOB (FT)
0.5
1.0
1.5
2.0
2.5
1
2
3
4
5
6
7
8
3/5
3/12
3/19
3/26
4/2
4/9
4/16
4/23
4/30
5/7
5/14
5/21
5/28
1973

FIGURE 11

FIGURE 15


FINAL CLARIFIER SLUDGE DETENTION TIME - CSDT
CSDT (HOURS)
5
4
3
2
1
0
< 1 >
Ave
1.50
< 2 >
Ave
3.08
< 3 >
Ave
0.57
< 4 >
Ave
0.96
< 5 >
Ave
0.81
< 6 >
Ave
0.64
< 7 >
Ave
0.76
OVERLOAD
OVERLOAD
Optimum Range for CSDT
(0.85 - 1.20)
5/5
5/12
5/19
5/26
6/2
6/9
6/16
6/23
6/30
7/7
7/14
7/21
7/28
1973

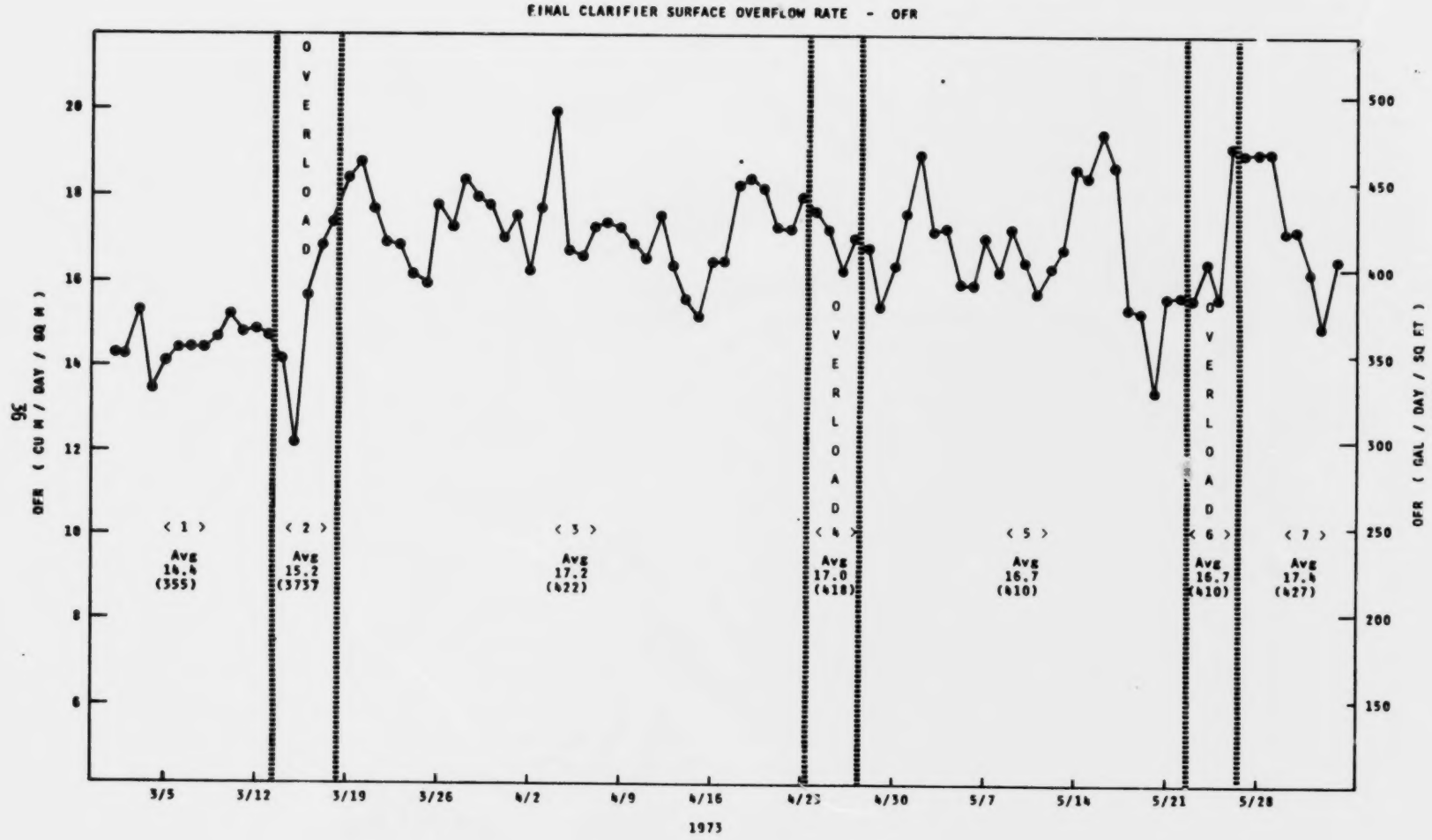

FINAL CLARIFIER SURFACE OVERFLOW RATE - OFR
OFR (CU M / DAY / SQ M)
OFR (GAL / DAY / SQ FT)
OVERLOAD
OVERLOAD
OVERLOAD
< 1 >
Avg
14.4
(355)
< 2 >
Avg
15.2
(3737
< 3 >
Avg
17.2
(422)
< 4 >
Avg
17.0
(418)
< 5 >
Avg
16.7
(410)
< 6 >
Avg
16.7
(410)
< 7 >
Avg
17.6
(427)
3/5
3/12
3/19
3/26
4/2
4/9
4/16
4/23
4/30
5/7
5/14
5/21
5/28
1973

FIGURE 16

EFFLUENT QUALITY

During the project final effluent degraded as load to the secondary system increased (Figures 8, 9, and 17). This is documented by the seven-day moving averages of secondary organic loadings and final effluent quality (Figures 18 and 19).

Figure 18 reveals that: (1) Final Effluent BOD 5 is a function of loading; (2) the ability to maintain better effluent quality during the "overload" conditions improved as the technical support project progressed. Final effluent was severely degraded during Period <2>, but when the overload was greater in both magnitude and duration during Period <4>, less degradation occurred and final effluent quality recovered as soon as the overload condition passed through the system. Figure 19 also illustrates the facility's increased ability to accommodate shock loads because of the improved sludge quality and process status which were accomplished by use of the demonstrated operational control procedures.

Note the closeness of the turbidity plots and those for final effluent total suspended solids. The plant operator is able to obtain a rapid indication of process response to control adjustments and for that reason the Turbidity Test is highly recommended.

PROCESS EVALUATION

Figures 18 to 21 are included to demonstrate the use of seven-day moving average plots of selected data in assisting the plant personnel to evaluate loadings and response. The moving average plots "smooth out" the day-to-day rapid fluctuations and facilitate searching out related parameters. Figure 21 displays the merit of the utilization of "sludge units" to assist the operator in his decision for sludge wasting. The weight of waste sludge is plotted with two "age" graphs, the last two with inverted scales. The fact that sludge age decreases as waste sludge weight increases is evident and that the rapidly calculated AGE precludes the necessity for gravimetric determination of waste weight per day. At the Anderson treatment facility, the operators were trained to evaluate settling characteristics, WCR, DOB, AGE, and final effluent quality for making decisions on waste sludge flow.

For process evaluation the operator must have usable data pertinent to the treatment facility, and it must be

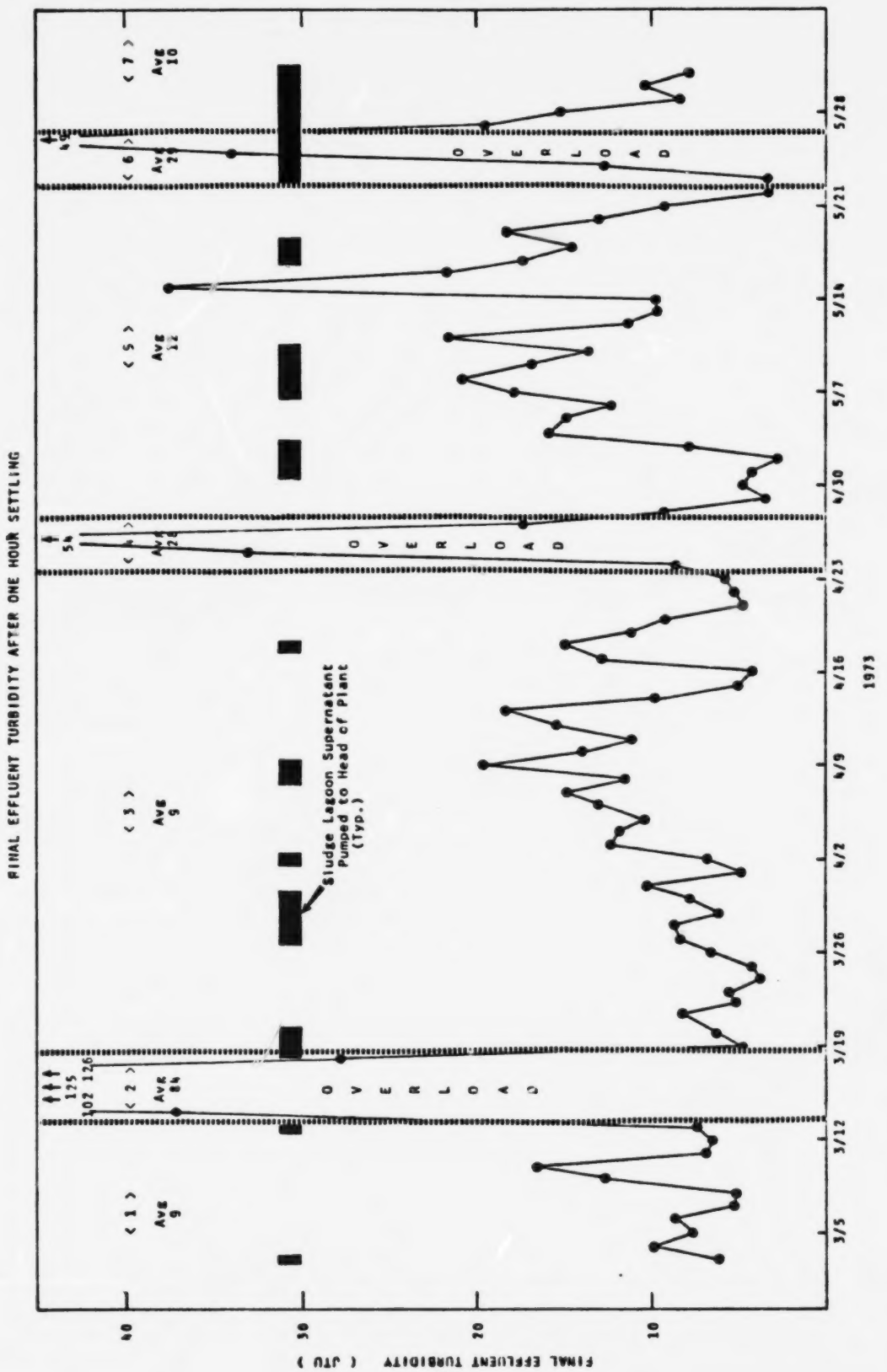
organized and displayed in a form which enables him to actually accomplish such process evaluation. Certain data should be displayed graphically so that comparison, trend evaluation, and finally, sound judgments can be made on effluent quality responses to process characteristics. The Waste Treatment Group has found that six trend charts generally provide the minimum data display for secondary process evaluation. These include:

1) Settling Curves (SSV)
2) Concentration Curves (ATC, RSC, and SSC)
3) Turbidity Curve (1-Hour after settling)
4) Waste Sludge Unit Curve (TXU)
5) Depth of Sludge Blanket (DOB)
6) Clarifier Sludge Detention Time (CSDT)

Sludge Age was substituted for the Waste Sludge Unit Curve at the OCF facility. During the project the significance of loadings to the plant indicate that it too should be displayed.

The remaining process relationship data, such as WCR, ADT, OFR, etc, do not usually fluctuate widely nor rapidly enough to warrant routine plotting on continuous trend charts. These values should be posted on the tabularized data sheets routinely and displayed for convenient use and reference when needed. This readily accessible display of both curves and data will help the operator remain aware of most variables that govern plant performance.

FIGURE 17


FINAL EFFLUENT TURBIDITY AFTER ONE HOUR SETTLING
FINAL EFFLUENT TURBIDITY (JTU)
60
50
40
30
20
10
3/5
3/12
3/19
3/26
4/2
4/9
4/16
4/23
4/30
5/7
5/14
5/21
5/28
1973
< 1 >
Ave 9
< 2 >
Ave 84
125
102 126
< 3 >
Ave 9
< 4 >
Ave 28
54
< 5 >
Ave 12
< 6 >
Ave 29
< 7 >
Ave 10
O V E R L O A D
Sludge Lagoon Supernatant Pumped to Head of Plant (Typ.)

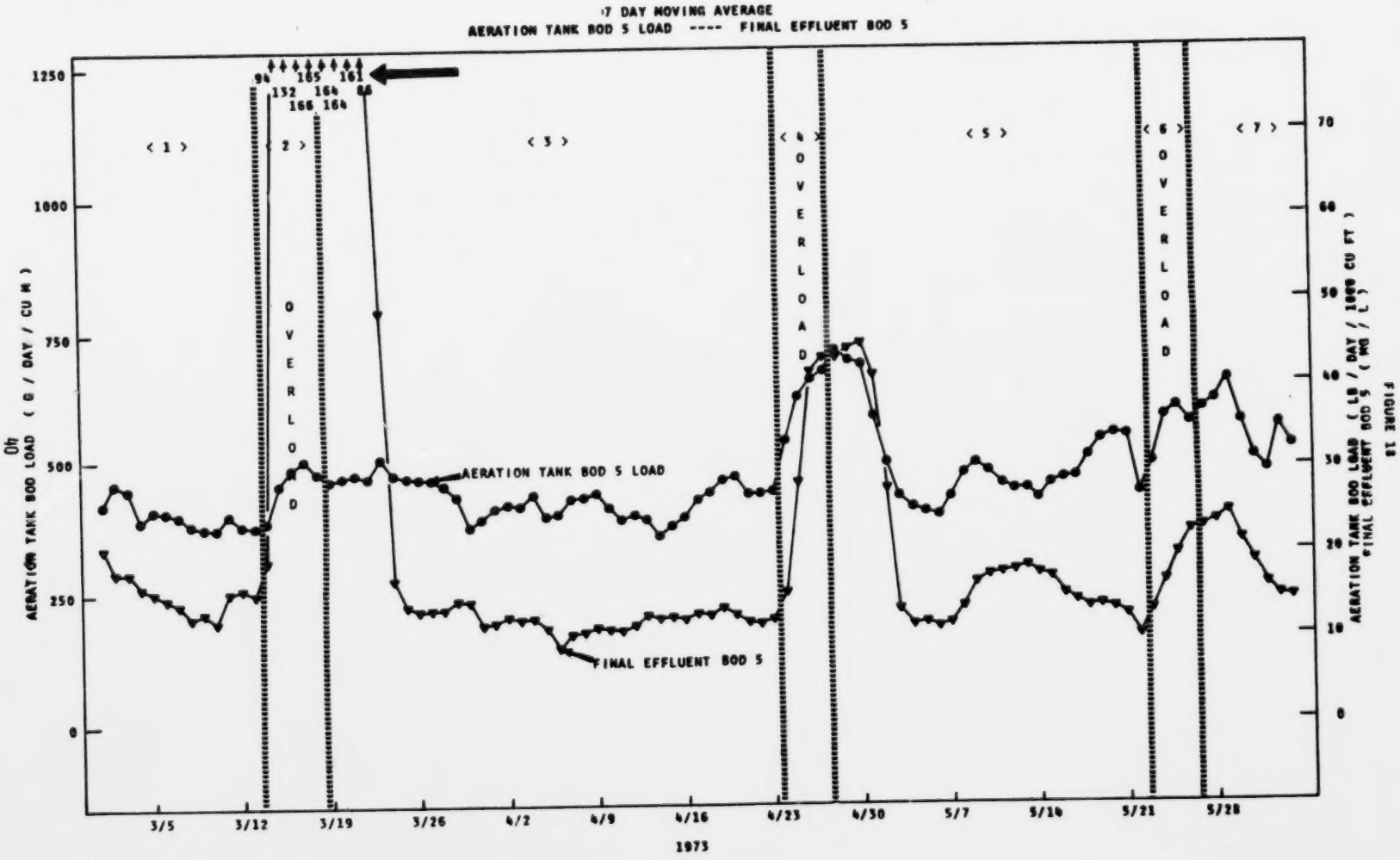

7 DAY MOVING AVERAGE
AERATION TANK BOD 5 LOAD ---- FINAL EFFLUENT BOD 5
AERATION TANK BOD LOAD (# / DAY / CU M)
AERATION TANK BOD LOAD (LB / DAY / 1000 CU FT)
FINAL EFFLUENT BOD 5 (MG / L)
1250
1000
750
500
250
0
70
60
50
40
30
20
10
0
94
132
166
165
164
164
161
86
< 1 >
< 2 >
< 3 >
< 4 >
< 5 >
< 6 >
< 7 >
OVERLOAD
OVERLOAD
OVERLOAD
AERATION TANK BOD 5 LOAD
FINAL EFFLUENT BOD 5
3/5
3/12
3/19
3/26
4/2
4/9
4/16
4/23
4/30
5/7
5/14
5/21
5/28
1973

FIGURE 13

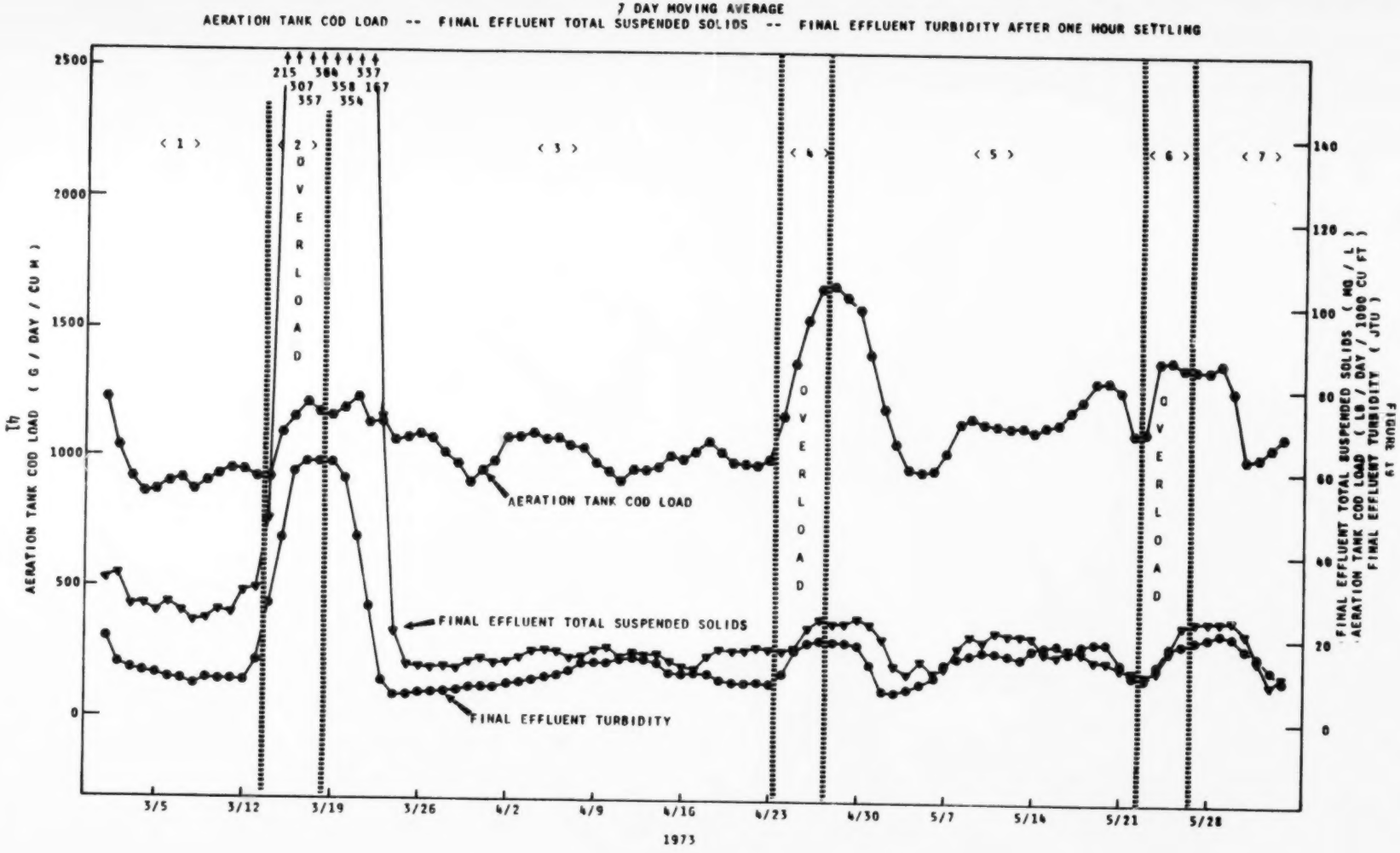

7 DAY MOVING AVERAGE
AERATION TANK COD LOAD -- FINAL EFFLUENT TOTAL SUSPENDED SOLIDS -- FINAL EFFLUENT TURBIDITY AFTER ONE HOUR SETTLING
AERATION TANK COD LOAD (G / DAY / CU M)
lb
2500
2000
1500
1000
500
0
215 304 337
307 358 167
357 354
< 1 >
< 2 >
< 3 >
< 4 >
< 5 >
< 6 >
< 7 >
OVERLOAD
OVERLOAD
OVERLOAD
AERATION TANK COD LOAD
FINAL EFFLUENT TOTAL SUSPENDED SOLIDS
FINAL EFFLUENT TURBIDITY
3/5
3/12
3/19
3/26
4/2
4/9
4/16
4/23
4/30
5/7
5/14
5/21
5/28
1973
140
120
100
80
60
40
20
0
FINAL EFFLUENT TOTAL SUSPENDED SOLIDS (MG / L)
AERATION TANK COD LOAD (LB / DAY / 1000 CU FT)
FINAL EFFLUENT TURBIDITY (JTU)

FIGURE 19

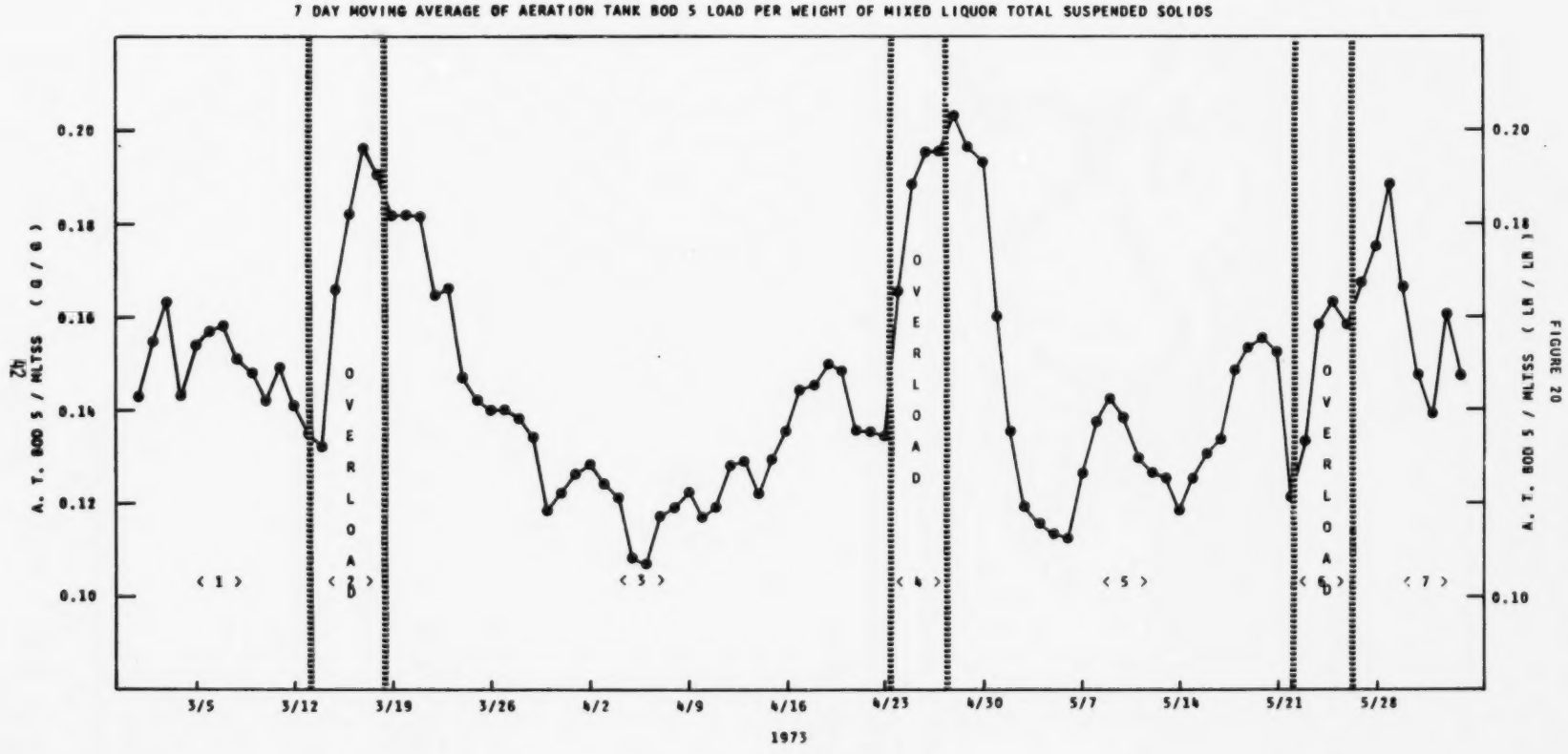

7 DAY MOVING AVERAGE OF AERATION TANK BOD 5 LOAD PER WEIGHT OF MIXED LIQUOR TOTAL SUSPENDED SOLIDS
A. T. BOD 5 / MLTSS (LB / LB)
0.20
0.18
0.16
0.14
0.12
0.10
OVERLOAD
< 1 >
< 2 >
< 3 >
< 4 >
< 5 >
< 6 >
< 7 >
3/5
3/12
3/19
3/26
4/2
4/9
4/16
4/23
4/30
5/7
5/14
5/21
5/28
1973

FIGURE 20

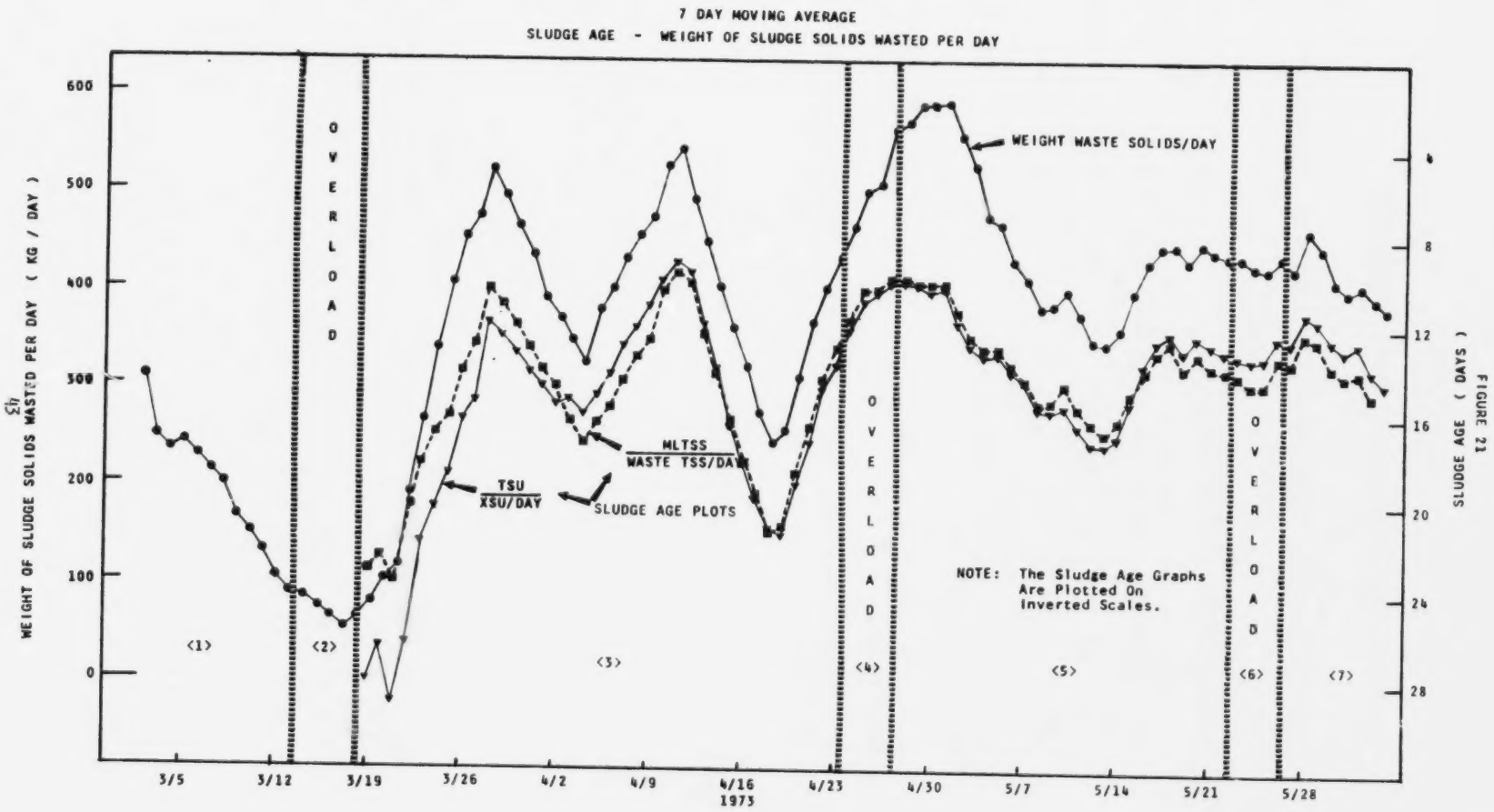

7 DAY MOVING AVERAGE
SLUDGE AGE - WEIGHT OF SLUDGE SOLIDS WASTED PER DAY
WEIGHT OF SLUDGE SOLIDS WASTED PER DAY (KG / DAY)
SLUDGE AGE (DAYS)
600
500
400
300
200
100
0
4
8
12
16
20
24
28
OVERLOAD
WEIGHT WASTE SOLIDS/DAY
MLTSS
WASTE TSS/DAY
TSU
XSU/DAY
SLUDGE AGE PLOTS
NOTE: The Sludge Age Graphs Are Plotted On Inverted Scales.
<1>
<2>
<3>
<4>
<5>
<6>
<7>
3/5
3/12
3/19
3/26
4/2
4/9
4/16
1973
4/23
4/30
5/7
5/14
5/21
5/28

FIGURE 21

OPERATIONAL CONTROL PROBLEMS

The following operational control problems were identified.

WASTE FLOW CHARACTERISTICS

1. The most severe limitation to attaining consistently acceptable effluent quality at this facility was directly related to some of the overload "batch dumps" of high organic strength. Appendix G (Furnished by OCF) categorizes the waste flow from the various sources and the concentration of organic content. The problem of concurrent or excessive "dumps" was displayed during the technical support project.

2. pH of the waste stream fluctuated dramatically at times.

3. The waste was deficient in nutrients (nitrogen and phosphorus).

OPERATIONAL CONTROL CAPABILITY

1. Meters

At the start of the project only effluent flow and raw pH were metered. A return sludge meter was installed early in the project and a field probe D. O. analyzer was repaired.

2. Screening

The bar screen and basket provide insufficient screening. This was demonstrated by the frequent need to manually clean a check valve in the primary sludge line before primary sludge could be pumped from the clarifiers to the digester. This clogging at times resulted in inconsistent primary sludge withdrawal and resultant carry-over of sludge to the secondary system.

3. Mixing tanks

These tanks provided only flow equalization and mixing. They could not easily be operated to equalize or "dampen" shock organic loads.

4. pH

Bulk storage of acid and caustic was provided, but the adjustment of caustic flow to the waste stream was a manual operation. The pH meter sampling line plugged frequently and resulted in extremes of pH.

5. Primary clarifiers

The problem with sludge withdrawal has been noted under "Screening".

6. Aeration tanks and air supply

Tank number 3 displayed consistently lower D. O. levels. The real problem was with the air supply itself, because it appears that sufficient blower capacity was available. However, a common header supplied the three aeration tanks, the two mixing tanks, and the aerobic digester. In addition only two blowers could be operated concurrently to prevent electrical overloading. These two facts resulted in an inability to distribute air as required by process demands.

7. Secondary clarifiers

Distribution of flow to the three rectangular clarifiers could only be accomplished by setting blocks over the overflow ports in the distribution box. Pulsing of the flow into the clarifiers and air entrainment hindered floc formation. The sludge draft tubes plugged when CSF was reduced below 11.4 l/sec (180 gpm) with three secondary clarifiers on line.

8. Secondary coagulant aid system

The system to add coagulants to the distribution box following the aeration tanks had only one tank in which to mix a polymer solution and then feed the mixed solution to the process flow stream. When the tank emptied, the concentrated

polymer was added to the tank, filled with water and the solution added to the process stream without time for mixing. The solution flowed by gravity to the point of addition at the distribution box with a resultant inconsistency of feed rate.

9. Sludge lagoon

Pumping of sludge lagoon supernatant was necessitated to prevent the lagoon from overflowing into Drake Creek. This added varying and unpredictable amounts of nitrogen to the system, changed sludge quality, and colored the clarifier overflow green during the lagoon pumping operation. In addition, the sludge lagoon could cause an odor problem if the sludge floats to the lagoon surface.

APPENDIX

TABLE A-1

TREATMENT FACILITIES

OWENS-CORNING FIBERGLAS CORP., ANDERSON, SOUTH CAROLINA

BAR RACK & SCREEN CHAMBER

MAT LINE

Type.....Steel basket, manually cleaned

Dimensions.....1.83 M x 1.24 M x 1.24 M
(6 FT x 4 FT x 4 FT)

Steel basket is covered with expanded metal with diamond-shaped openings giving a 48% net open area

MAIN LINE

Type.....Bar rack, manually cleaned

Bar Thickness.....5.08 CM x 0.64 CM
(2 IN x 1/4 IN)

Bar Spacing.....1.27 CM
(1/2 IN)

MIXING TANKS

Number.....2

Dimensions.....1 - 10.36 M dia. x 4.57 M depth
(34 FT dia. x 15 FT depth)

2 - 15.24 M dia. x 5.18 M depth
(50 FT dia. x 17 FT depth)

Tank Volumes.....1 - 385.64 CU M
(102000 GAL)

2 - 182.4 CU M/M depth
(14700 GAL/FT depth)

Tank 1 remains full at all times, Tank 2 depth varies with flow.

TABLE A-1 (continued)

MIXING TANK PUMPS

Number.....2

Type.....Direct couple, centrifugal

Capacity(each).....3.596 CU M/MIN
(950 GPM)

PRIMARY CLARIFIERS

Number.....5

Dimensions(each).....4.27 M dia. x 2.74 M depth
(14 FT dia. x 9 FT depth)

Type.....Circular, peripheral feed

	EACH	TOTAL
Clarifier Surface Area...	14.3 SQ M..... (154 SQ FT....	71.5 SQ M 770 SQ FT)
Clarifier Volume.....	39.23 CU M..... (1385 CU FT.. (10363 GAL....	196 CU M 6927 CU FT) 51815 GAL)

Clarifier Weir Length, Total.....66.9 M
(219.5 FT)

PRIMARY SLUDGE PUMPS

Number.....2

Type.....Direct couple, centrifugal

Capacity(each).....0.757 CU M/MIN
(200 GPM)

AERATION TANK INFLUENT PUMP

Number.....1

Type.....Direct couple, centrifugal

Capacity.....3.217 CU M/MIN
(850 GPM)

TABLE A-1 (continued)

AERATION TANKS

Number.....3

Type.....Rectangular, concrete

Dimensions(each).....15.24 M x 7.62 M x 4.57 M
(50 FT x 25 FT x 15 FT)

	EACH	TOTAL
Surface Area.....	116 SQ M	348 SQ M
	(1250 SQ FT	3750 SQ FT)
Volume.....	531 CU M	1593 CU M
	(18750 CU FT	56250 CU FT)
	(140250 GAL	420750 GAL)

AERATION EQUIPMENT

BLOWERS

Number.....3

Size.....1 - 28.3 CU M/MIN
(1000 SCFM)

2 - 19.8 CU M/MIN
(700 SCFM)

3 - 28.3 CU M/MIN
(1000 SCFM)

Common header to 3 aeration tanks, 2 mixing tanks and 1 aerobic digester.

DIFFUSERS

Type.....Precision

Number.....3 Headers/Tank.....22 Diffusers/Header

TABLE A-1 (continued)

SECONDARY CLARIFIERS

Number.....3

Type.....Rectangular

Dimensions(each).....15.24 M x 3.05 M x 2.59 M
(50 FT x 10 FT x 8.5 FT)

	EACH	TOTAL
Surface Area	46 SQ M (500 SQ FT)	139 SQ M (1500 SQ FT)
Volume	120 CU M (4250 CU FT) (31800 GAL)	361 CU M (12750 CU FT) (95400 GAL)

Sludge Mechanism.....Scraper

Sludge scraped to influent end of clarifier to sump - surface scum to trough at effluent end.

DIGESTER

Number.....1

Type.....Aerobic

Dimensions.....13.72 M dia. x 7.62 M depth
(45 FT dia. x 25 FT depth)

Volume.....1126.5 CU M
(39900 CU FT)
(297400 GAL)

FINAL EFFLUENT PUMP

Number.....1

Type.....Direct couple, centrifugal

Capacity.....3.596 CU M/MIN
(950 GPM)

TABLE A-1 (continued)

RETURN SLUDGE PUMPS

Number.....2

Type.....Direct couple, centrifugal

Capacity(each).....0.757 CU M/MIN (200 GPM)

SCUM TROUGH PUMP

Number.....1

Type.....Direct couple, centrifugal

Capacity.....0.606 CU M/MIN (160 GPM)

METERS

RETURN SLUDGE FLOW

Open flow nozzle meter with continuous recorder

Capacity, maximum.....1.514 CU M/MIN (400 GPM)

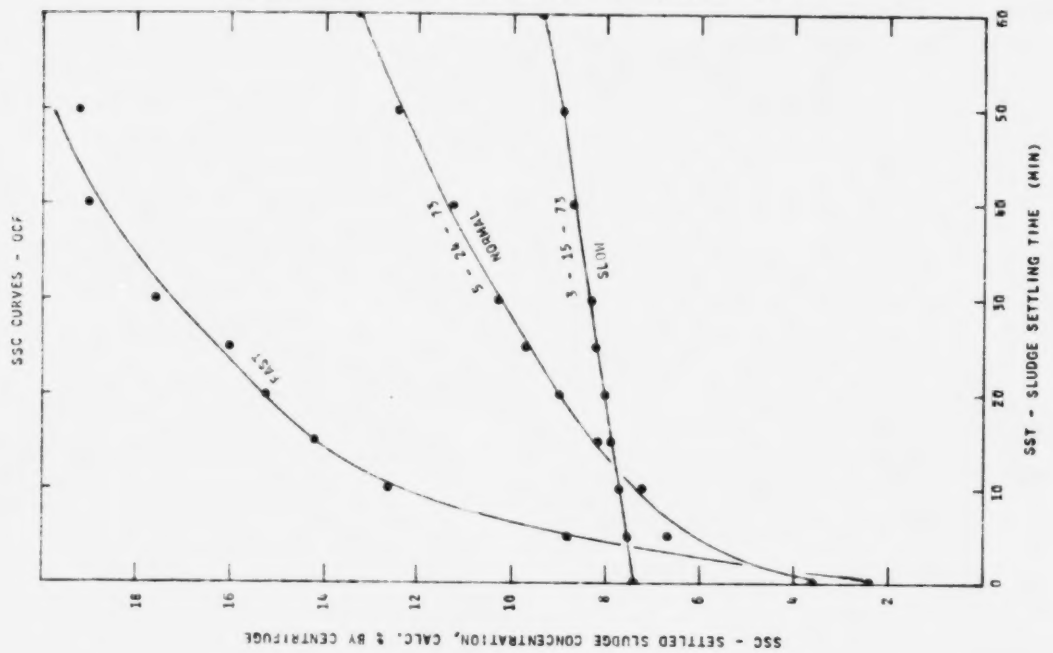
FINAL EFFLUENT FLOW

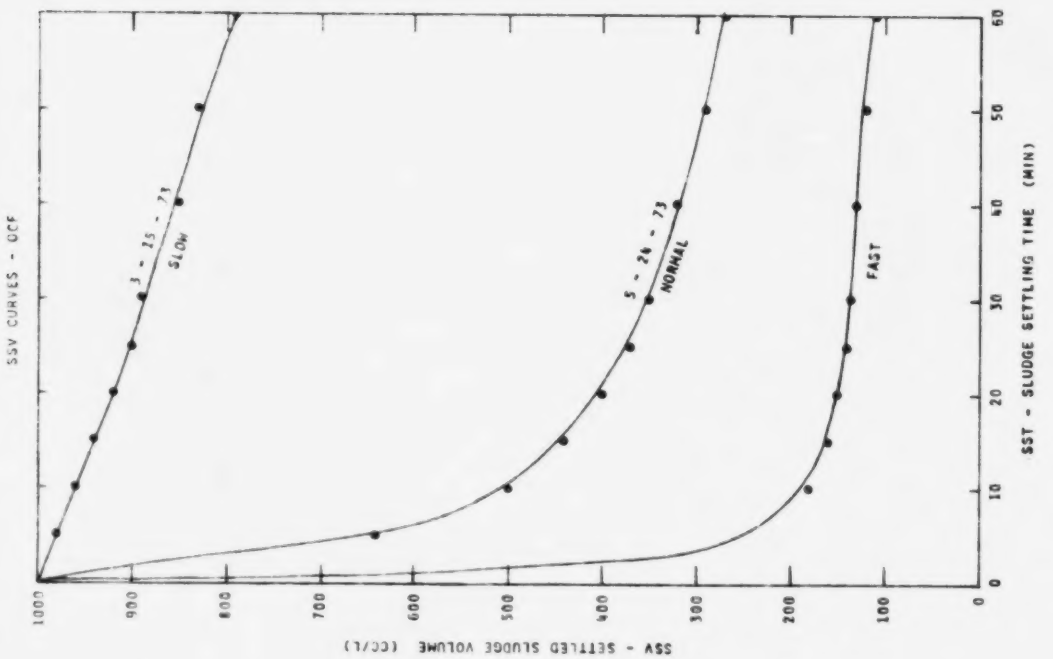
Parshall Flume with continuous recorder

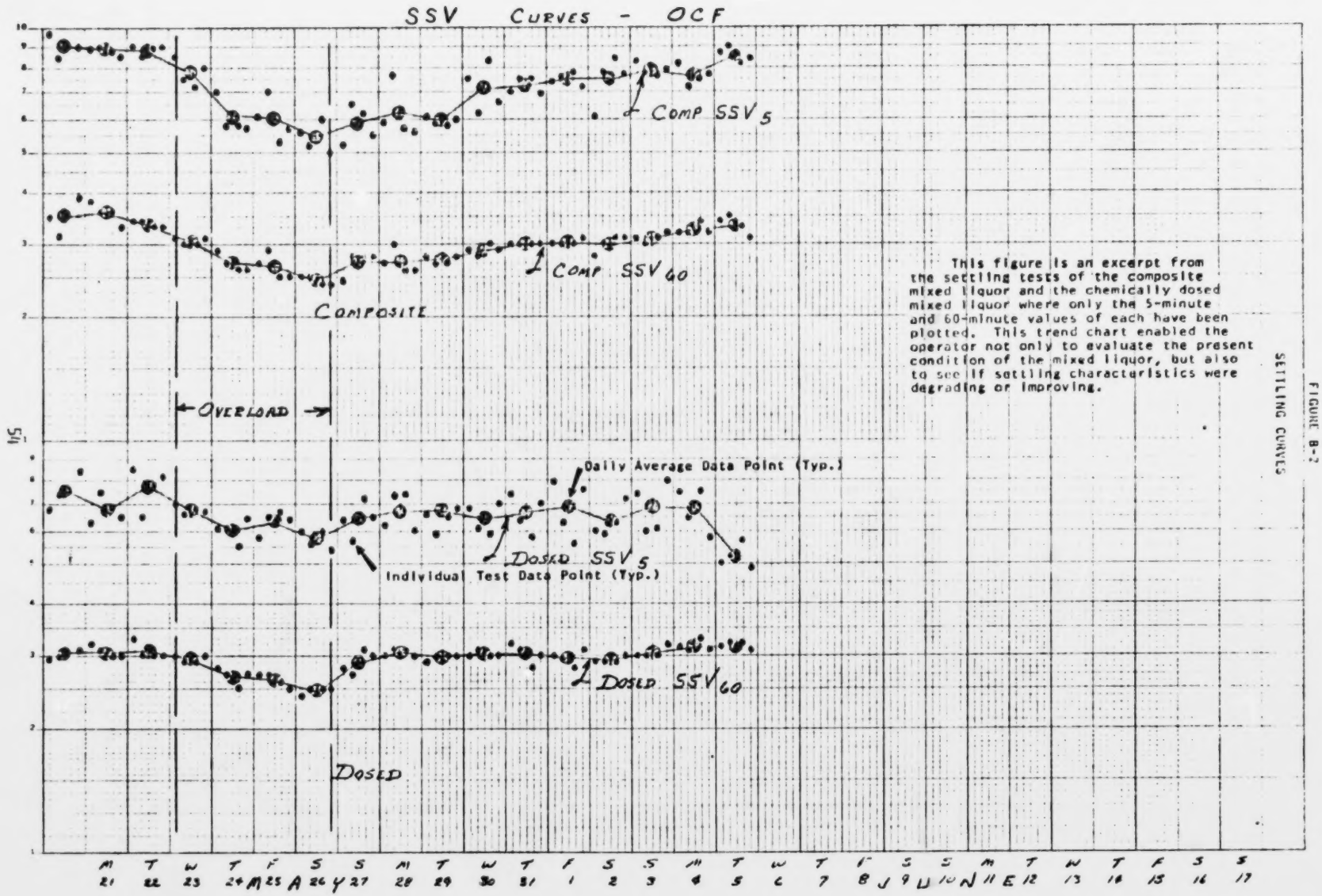
Capacity, maximum.....3.785 CU M/MIN (1000 GPM)

FIGURE B-1

ILLUSTRATIVE SETTLING AND CONCENTRATION CURVES
OWENS-CORNING FIBERGLAS CORPORATION, ANDERSON, SOUTH CAROLINA






SSV Curves - OCF
Comp SSV5
Comp SSV60
Composite
Overload
Daily Average Data Point (Typ.)
Dosed SSV5
Individual Test Data Point (Typ.)
Dosed SSV60
Dosed
SSV
M T W T F S S M T W T F S S M T W T F S S M T W T F S S
21 22 23 24 M 25 A 26 Y 27 28 29 30 31 1 2 3 4 5 6 7 8 J 9 U 10 N 11 E 12 13 14 15 16 17

This figure is an excerpt from the settling tests of the composite mixed liquor and the chemically dosed mixed liquor where only the 5-minute and 60-minute values of each have been plotted. This trend chart enabled the operator not only to evaluate the present condition of the mixed liquor, but also to see if settling characteristics were degrading or improving.

SETTLING CURVES

FIGURE B-2

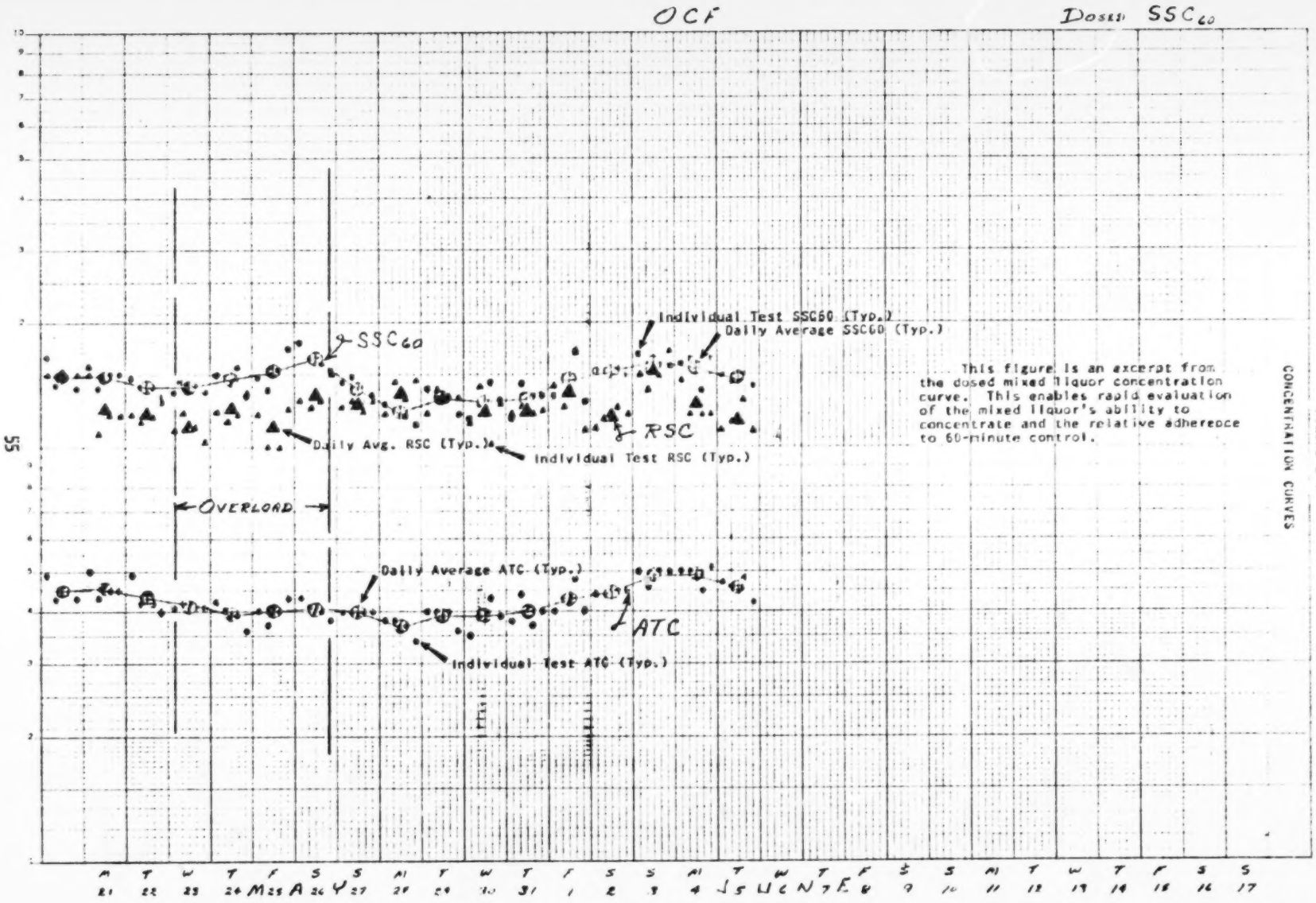

OCF
Dosed SSC60
SSC60
Individual Test SSC60 (Typ.)
Daily Average SSC60 (Typ.)
RSC
Daily Avg. RSC (Typ.)
Individual Test RSC (Typ.)
OVERLOAD
Daily Average ATC (Typ.)
ATC
Individual Test ATC (Typ.)
SS
This figure is an excerpt from the dosed mixed liquor concentration curve. This enables rapid evaluation of the mixed liquor's ability to concentrate and the relative adherence to 60-minute control.
CONCENTRATION CURVES
FIGURE B-1

FIGURE B-4

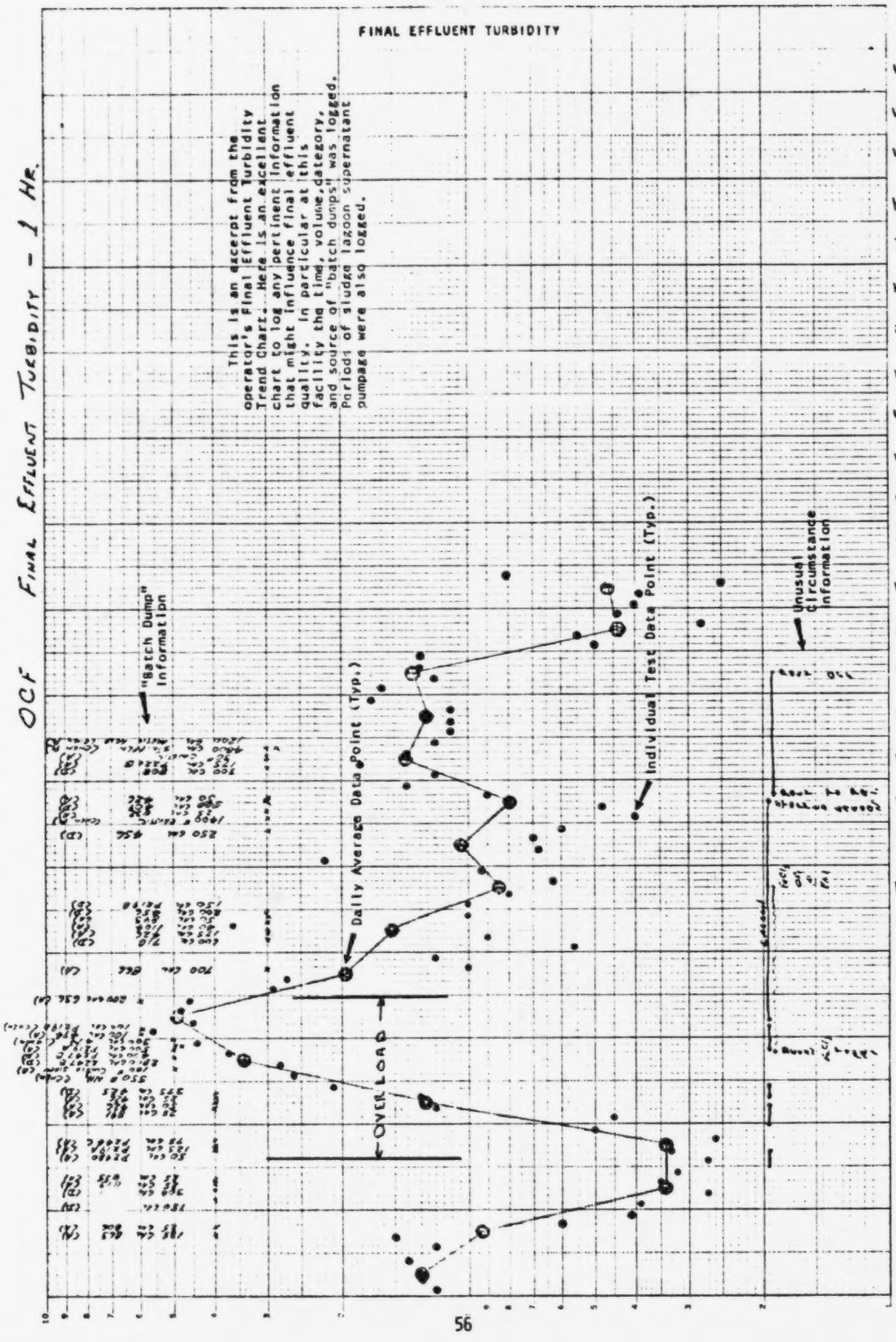

FINAL EFFLUENT TURBIDITY
OCF Final Effluent Turbidity - 1 Hr.
This is an excerpt from the operator's Final Effluent Turbidity Trend Chart. Here is an excellent chart to log any pertinent information that might influence final effluent quality. In particular at this facility the time, volume, category, and source of "batch dumps" was logged. Periods of sludge lagoon supernatant pumpage were also logged.
"Batch Dump" Information
Daily Average Data Point (Typ.)
Individual Test Data Point (Typ.)
Unusual Circumstance Information
OVERLOAD

TABLE NO. C-1

SUMMARY OF PLANT FLOWS

OWENS-CORNING FIBERGLAS CORPORATION, ANDERSON, SOUTH CAROLINA

	DATES	3-1 to 3-13	3-14 to 3-18	3-19 to 4-23	4-24 to 4-27	4-28 to 5-22	5-23 to 5-26	5-27 to 6-3	3-19 to 6-3	3-19 to 6-3 -4 DAYS
	PERIOD	<1>	<2>	<3>	<4>	<5>	<6>	<7>	<8>	<9>
PLANT FLOWS										
AFI	(CU M/DAY)	2017.8	2120.0	2398.2	2375.1	2327.0	2327.0	2422.8	2372.8	2372.4
	(MGD)	0.5331	0.5601	0.6336	0.6275	0.6148	0.6148	0.6401	0.6269	0.6268
RSF	(CU M/DAY)	2093.1	1411.8	1211.2	1286.9	1207.4	1003.0	1029.5	1184.7	1188.5
	(MGD)	0.553	0.373	0.320	0.340	0.319	0.265	0.272	0.313	0.314
TFL	(CU M/DAY)	4143.4	3540.9	3658.2	3733.9	3584.8	3379.2	3492.4	3607.1	3610.1
	(MGD)	1.0947	0.9355	0.9665	0.9865	0.9471	0.8928	0.9227	0.9530	0.9538
XSF	(CU M/DAY)	32.5	9.0	48.8	71.9	50.3	49.2	40.1	49.5	49.5
	(MGD)	0.0086	0.0024	0.0129	0.0190	0.0133	0.0130	0.0106	0.0131	0.0130
CSF	(CU M/DAY)	2125.6	4420.8	1260.0	1358.8	1257.7	1052.2	1069.6	1234.2	1237.6
	(MGD)	0.5616	0.3754	0.3329	0.3590	0.3323	0.2780	0.2826	0.3261	0.3270
PSF	(CU M/DAY)	60.18	60.18	65.10	63.97	63.59	76.08	49.58	63.97	63.97
	(MGD)	0.0159	0.0159	0.0172	0.0169	0.0168	0.0201	0.0131	0.0169	0.0169

TABLE NO. C-2

SUMMARY OF PRIMARY SYSTEM LOADINGS, DETENTION TIMES, AND REDUCTIONS

OWENS-CORNING FIBERGLAS CORPORATION, ANDERSON, SOUTH CAROLINA

DATES		3-1 to 3-13	3-14 to 3-18	3-19 to 4-23	4-24 to 4-27	4-28 to 5-22	5-23 to 5-26	5-27 to 6-3	3-19 to 6-3	3-19 to 6-3 -4 DAYS
PERIOD		<1>	<2>	<3>	<4>	<5>	<6>	<7>	<8>	<9>
PRIMARY SYSTEM PARAMETERS										
WT BOD 5 TO PRI	(KG/DAY)	833.0	957.9	838.0	1646.2	839.4	1329.3	889.8	911.6	877.1
	(LB/DAY)	1835	2110	1846	3626	1849	2928	1960	2008	1932
WT COD TO PRI	(KG/DAY)	3079.4	3396.3	3157.1	4337.0	3421.7	4776.0	3119.4	3384.5	3350.9
	(LB/DAY)	6783	7481	6954	9553	7537	10520	6871	7455	7381
WT TSS TO PRI	(KG/DAY)	1026.9	950.2	1113.6	945.6	1102.3	1317.9	974.2	1097.3	1092.3
	(LB/DAY)	2262	2093	2453	2083	2428	2903	2146	2417	2406
PDT (HOURS)		2.3	2.3	2.0	1.9	1.8	2.1	1.9	1.9	1.9
OVERFLOW	(CU M/SQ M/DAY)	28.1	36.2	33.4	35.5	38.0	32.2	35.6	35.1	35.2
	(GAL/SQ FT/DAY)	689	888	818	870	931	790	872	861	864
REDUCTIONS										
PRI BOD 5 REDUCTION	(%)	25.2	12.2	20.4	13.3	16.0	12.8	5.9	16.4	17.7
PRI COD REDUCTION	(%)	52.6	38.4	38.4	22.5	49.4	41.1	45.3	46.2	48.6
PRI TSS REDUCTION	(%)	80.1	73.3	70.9	56.2	69.1	86.1	67.1	70.3	70.6

TABLE NO. C-3

SUMMARY OF SECONDARY SYSTEM LOADINGS, DETENTION TIMES, AND REDUCTIONS

OWENS-CORNING FIBERGLAS CORPORATION, ANDERSON, SOUTH CAROLINA

DATES	3-1 to 3-13	3-14 to 3-18	3-19 to 4-23	4-24 to 4-27	4-28 to 5-22	5-23 to 5-26	5-27 to 6-3	3-19 to 6-3	3-19 to 6-3 -4 DAYS
PERIOD	<1>	<2>	<3>	<4>	<5>	<6>	<7>	<8>	<9>
SECONDARY SYSTEM PARAMETERS									
AERATION TANKS									
WT P E BOD 5 (KG/DAY)	622.8	841.2	666.9	1427.3	705.0	1159.5	837.1	762.2	722.3
(LB/DAY)	1372	1853	1469	3144	1553	2554	1844	1679	1591
WT P E COD (KG/DAY)	1460.0	2091.5	1627.1	3361.4	1731.5	2812.0	1707.4	1820.9	1723.8
(LB/DAY)	3216	4607	3584	7404	3814	6194	3761	4011	3797
WT P E TSS (KG/DAY)	204.3	253.3	323.7	414.0	340.5	183.4	320.5	326.4	321.4
(LB/DAY)	450	558	713	912	750	404	706	719	708
ADT @ AFI (HOURS)	18.9	18.0	15.9	16.1	16.4	16.4	15.8	16.1	16.1
ADT @ TFL (HOURS)	9.2	10.8	10.4	10.2	10.7	11.3	10.9	10.6	10.6
BOD 5 LOADING (G/CU M)	390.4	526.4	417.6	894.4	441.6	726.4	524.8	476.8	452.8
(LB/k CU FT)	24.4	32.9	26.1	55.9	27.6	45.4	32.8	29.8	28.3
COD LOADING (G/CU M)	915.2	1310.4	1019.2	2105.6	1084.8	1761.6	1070.4	1140.8	1080.0
(LB/k CU FT)	57.2	81.9	63.7	131.6	67.8	110.1	66.9	71.3	67.5
WT BOD 5/WT MLTSS	0.15	0.21	0.13	0.26	0.13	0.21	0.15	0.14	0.14
WT RSTSS/WT BOD 5	16.9	12.7	17.0	8.2	17.0	9.3	12.9	15.7	16.2
WT MLTSS/WT WASTE SS/DAY	38.8	50.6	14.8	9.7	14.1	12.8	13.5	14.1	14.2
WT SOLIDS GEN/WT BOD 5	0.70	---	2.16	1.22	3.02	2.67	3.10	2.55	2.52
WT SOLIDS GEN/WT COD	0.63	---	0.90	0.47	1.14	1.02	1.40	1.02	1.01
FINAL CLARIFIERS									
CDT (HOURS)	2.1	2.4	2.4	2.3	2.4	2.6	2.5	2.4	2.4
OFR (CU M/SQ M/DAY)	14.4	15.2	17.2	17.0	16.7	16.7	17.4	17.0	17.0
(GAL/SQ FT/DAY)	355	373	422	418	410	410	427	418	418
DOB (M)	1.37	0.80	2.25	2.04	2.15	2.28	2.22	2.20	2.21
(FT)	4.5	2.6	7.4	6.7	7.1	7.5	7.3	7.3	7.3
CSDT (HOURS)	1.5	3.1	0.6	1.0	0.8	0.6	0.8	0.7	0.7
WT BOD 5 DISCHARGED (KG)	30.4	448.5	29.5	161.6	31.3	78.5	34.5	39.9	33.1
(LB)	67	988	65	356	69	173	76	88	73
WT COD DISCHARGED (KG)	420	2007	370	1000	378	1187	435	454	391
(LB)	926	4421	814	2202	832	2614	959	1001	861
WT TSS DISCHARGED (KG)	58.6	962.0	34.5	84.9	34.9	81.7	27.2	39.0	34.5
(LB)	129	2119	76	187	77	180	60	86	76
REDUCTIONS									
SEC BOD 5 REDUCTION (%)	95.1	46.7	95.6	88.7	95.6	93.2	95.9	94.8	95.4
SEC COD REDUCTION (%)	71.2	4.0	82.3	70.3	78.2	57.8	74.5	75.0	77.3
SEC TSS REDUCTION (%)	71.3	---	89.3	79.5	89.7	55.4	91.5	88.0	89.3

TABLE NO. C-4

SUMMARY OF PLANT LOADINGS AND PROCESS RESPONSES

OWENS-CORNING FIBERGLAS CORPORATION, ANDERSON, SOUTH CAROLINA

DATES	3-1 to 3-13	3-14 to 3-18	3-19 to 4-23	4-24 to 4-27	4-28 to 5-22	5-23 to 5-26	5-27 to 6-3	3-19 to 6-3	3-19 to 6-3 -4 DAYS
PERIOD	<1>	<2>	<3>	<4>	<5>	<6>	<7>	<8>	<9>
PROCESS RELATIONSHIPS									
ATC (%)	9.35	6.94	6.68	7.73	6.06	4.02	4.14	6.13	6.15
RSC (%)	17.03	16.67	16.98	19.66	15.38	11.96	13.00	15.92	15.93
SLR	1.82	2.47	2.54	2.54	2.56	2.98	3.16	2.63	2.63
CSP (%)	124	75	66	65	66	52	47	63	64
CFP (%)	105	67	52	57	54	45	44	52	52
CSP/CFP	1.18	1.12	1.27	1.14	1.22	1.16	1.07	1.21	1.23
DOB (M)	1.37	0.80	2.25	2.04	2.15	2.28	2.27	2.20	2.21
(FT)	4.51	2.63	7.39	6.71	7.08	7.50	7.29	7.25	7.28
BLT (FRACTION)	0.47	0.69	0.13	0.21	0.17	0.12	0.14	0.15	0.14
ASU	0.0393	0.0292	0.0281	0.0325	0.0245	0.0126	0.0174	0.0252	0.0253
CSU	0.0059	0.0077	0.0014	0.0027	0.0017	0.0009	0.0011	0.0015	0.0014
TSU	0.0453	0.0369	0.0295	0.0282	0.0272	0.0178	0.0185	0.0273	0.0273
SDR	7.21	4.46	36.59	13.68	15.55	18.83	15.48	25.45	26.14
CSDT (HRS)	1.5	3.1	0.6	1.0	0.8	0.6	0.8	0.7	0.7
1000 x XSU/DAY	1.420	0.654	2.190	3.782	2.063	1.541	1.382	2.176	2.152
AGE (DAYS)	31.9	56.4	13.5	7.5	13.2	11.6	13.4	12.5	12.7
TURBIDITY 1-HOUR (JTU)	9	84	9	28	12	29	10	12	11
HYDRAULIC LOADINGS									
ADT @ AFI (HRS)	18.9	18.0	15.9	16.1	16.4	16.4	15.8	16.1	16.1
ADT @ TFL (HRS)	9.2	10.8	10.4	10.2	10.7	11.3	10.9	10.6	10.6
CDT (HRS)	2.1	2.4	2.4	2.3	2.4	2.6	2.5	2.4	2.4
OFR (CU M/SQ M/DAY)	14.4	15.2	17.2	17.0	16.7	16.7	17.4	17.0	17.0
OFR (GAL/SQ FT/DAY)	355	373	422	418	410	410	427	418	418
BOD 5 LOADINGS									
BOD 5/AV (KG/1000AV)	390.4	526.4	417.6	894.4	441.6	726.4	524.8	476.8	452.8
(LB/1000AV)	24.4	32.9	26.1	55.9	27.6	45.4	32.8	29.8	28.3
BOD 5/MLTSS (WT/WT)	0.15	0.21	0.13	0.26	0.13	0.21	0.15	0.14	0.14
PURIFICATION PRESSURES									
ATC x ADT @ TFL	177	125	106	124	99	66	65	99	99
ATC x ADT / MG/L	0.276	0.180	0.250	0.207	0.215	0.088	0.128	0.201	0.216
RSU / 1000 AFI	178.2	116.9	86.8	106.6	80.8	51.7	55.5	80.8	81.1
RSTSS / BOD 5 (WT/WT)	16.9	12.7	17.0	8.2	17.0	9.3	12.9	15.7	16.2
SLUDGE QUALITY									
COMP SSV 5 (CC/L)	984	977	913	953	938	634	691	885	892
COMP SSV 60 (CC/L)	828	768	464	617	513	271	290	460	460
COMP SSC 60 (%)	11.43	8.98	14.84	12.62	12.06	14.94	14.24	13.77	13.76
DOSED SSV 5 (CC/L)	929	933	820	879	832	622	664	801	803
DOSED SSV 60 (CC/L)	607	606	407	458	383	268	299	383	384
DOSED SSC 60 (%)	15.83	11.81	16.57	17.21	15.87	15.08	13.85	16.02	16.02
COMP SCR	0.66	0.54	0.88	0.65	0.80	1.25	1.10	0.88	0.88
DOSED SCR	0.92	0.71	0.98	0.87	1.04	1.26	1.07	1.21	1.23
WCR	294	373	499	456	615	840	834	587	584
AEROBIC DIGESTER									
DETENTION TIME (DAYS)	18.7	18.7	17.3	17.6	17.7	14.8	22.7	17.6	17.6

TABLE NO. C-5

SUMMARY OF PLANT ORGANIC AND SOLIDS
CONCENTRATIONS AND PROCESS REDUCTIONS IN PERCENT

OWENS-CORNING FIBERGLAS CORPORATION, ANDERSON, SOUTH CAROLINA

	DATES	3-1 to 3-13	3-14 to 3-18	3-19 to 4-23	4-24 to 4-27	4-28 to 5-22	5-23 to 5-26	5-27 to 6-3	3-19 to 6-3	3-19 to 6-3 -4 DAYS
	PERIOD	<1>	<2>	<3>	<4>	<5>	<6>	<7>	<8>	<9>
BOD 5										
CONCENTRATIONS (MG/L)										
	RAW	416	468	350	691	360	578	371	385	366
	P. E.	312	417	278	607	302	514	351	323	302
	F. E.	15	226	12	69	14	34	14	17	14
REDUCTIONS (PERCENT)										
	PRIMARY	25.2	12.2	20.4	13.3	16.0	12.8	5.9	16.4	17.7
	SECONDARY	95.1	46.7	95.6	88.7	95.6	93.2	95.9	94.8	95.5
	PLANT	96.3	55.2	96.5	90.2	96.3	94.1	96.1	95.6	96.2
COD										
CONCENTRATIONS (MG/L)										
	RAW	1534	1684	1321	1820	1465	2072	1298	1429	1416
	P. E.	729	1041	680	1415	742	1225	719	771	748
	F. E.	209	998	154	421	163	516	179	192	184
REDUCTIONS (PERCENT)										
	PRIMARY	52.6	38.4	38.4	22.5	49.4	41.1	45.3	46.2	48.6
	SECONDARY	71.2	4.0	82.3	70.3	78.2	57.8	74.5	75.0	77.3
	PLANT	86.3	40.7	89.1	76.9	89.0	75.2	88.0	86.6	88.5
TSS										
CONCENTRATIONS (MG/L)										
	RAW	512	463	464	398	472	564	398	462	460
	P. E.	102	123	139	177	147	80	118	139	137
	F. E.	29	490	14	36	15	34	11	16	14
REDUCTIONS (PERCENT)										
	PRIMARY	80.1	73.3	70.9	56.2	69.1	86.1	67.1	70.3	70.6
	SECONDARY	71.3	--	89.3	79.5	89.7	55.4	91.5	88.0	89.3
	PLANT	94.3	0	96.9	91.0	96.8	93.8	97.2	96.4	96.8
MIXED LIQUOR										
MLTSS (MG/L)		2738	2569	3204	3569	3553	3431	3561	3385	3382
MLVSS (MG/L)		----	2296	3009	3457	3298	3057	3229	3149	3138
RETURN SLUDGE										
RSTSS (MG/L)		4854	6569	8009	8483	8527	8760	9405	8379	8399
RSVSS (MG/L)		----	----	7421	8039	8026	8309	8692	7821	7833
PRIMARY SLUDGE										
PSTSS (MG/L)		----	----	42344	40021	48177	57311	52634	48274	48157
PSVSS (MG/L)		----	----	40184	37739	45624	51179	48265	45281	45398

TABLE NO. C-6

SUMMARY OF PLANT NITROGEN AND PHOSPHORUS CONCENTRATIONS

OWENS-CORNING FIBERGLAS CORPORATION, ANDERSON, SOUTH CAROLINA

DATES		3-1 to 3-13	3-14 to 3-18	3-19 to 4-23	4-24 to 4-27	4-28 to 5-22	5-23 to 5-26	5-27 to 6-3	3-19 to 6-3	3-19 to 6-3 -4 DAYS
PERIOD		<1>	<2>	<3>	<4>	<5>	<6>	<7>	<8>	<9>
TOTAL PHOSPHORUS										
Raw	(MG/L)	0.54	0.54	0.52	0.62	0.58	0.75	0.67	0.59	0.58
Primary Effluent	(MG/L)	0.18	1.28	0.13	0.50	0.44	0.37	0.43	0.40	0.39
Final Effluent	(MG/L)	0.18	1.28	0.10	0.15	0.14	0.20	0.13	0.12	0.12
NITROGEN										
NH 3 - N										
Raw	(MG/L)	5.83	4.42	5.86	7.80	5.99	12.37	10.53	6.64	6.20
Primary Effluent	(MG/L)	2.10	2.84	2.82	6.67	5.82	8.22	9.50	4.13	3.70
Final Effluent	(MG/L)	0.56	2.44	1.27	2.15	3.33	1.80	10.77	2.54	2.55
TKN										
Raw	(MG/L)	14.08	13.26	10.37	9.67	11.48	18.75	18.00	11.77	11.45
Primary Effluent	(MG/L)	10.32	10.28	8.46	10.20	9.94	14.40	14.33	9.93	9.60
Final Effluent	(MG/L)	4.75	11.32	4.80	6.07	7.27	6.35	14.33	6.42	6.56
BOD 5 : N : P RATIO										
P E BOD 5		100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
N		3.4	2.8	3.3	1.8	3.6	4.3	4.6	3.4	3.4
P		0.15	0.15	0.14	0.10	0.16	0.10	0.16	0.14	0.14

NOTE: Total Phosphorus reported as P, mg/l; all Nitrogen as N, mg/l.

TABLE NO. D-1

CHART FOR DETERMINING POLYMER DOSAGE RATE FROM JAR TEST
DOSAGE IN MILLILITERS PER MINUTE

Milliliters of Polymer Solution added to the 1 liter sample

Flow	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.1	1.2
400	151	303	454	606	757	908	1060	1211	1362	1514	1665	1817
425	161	322	483	643	804	965	1126	1287	1448	1609	1769	1930
450	170	341	511	681	852	1022	1192	1363	1533	1703	1874	2044
475	180	360	539	719	899	1079	1259	1438	1618	1798	1978	2157
500	189	379	568	757	946	1136	1325	1514	1703	1893	2082	2271
525	199	397	596	795	394	1192	1391	1590	1788	1987	2186	2385
550	208	416	625	833	1041	1249	1457	1665	1874	2082	2290	2498
575	218	435	653	871	1088	1306	1523	1741	1959	2176	2394	2612
600	227	454	681	908	1136	1363	1590	1817	2044	2271	2498	2725
625	237	473	710	946	1183	1419	1656	1893	2129	2366	2602	2839
650	246	492	738	984	1230	1476	1722	1968	2214	2460	2706	2952
675	255	511	766	1022	1277	1533	1788	2044	2299	2555	2810	3066
700	265	530	795	1060	1325	1590	1855	2120	2385	2650	2914	3179
725	274	549	823	1095	1372	1646	1921	2195	2470	2744	3019	3293
750	284	568	851	1136	1419	1703	1987	2271	2555	2839	3123	3407
775	293	587	880	1173	1467	1760	2053	2347	2640	2933	3227	3520
800	303	606	908	1211	1514	1817	2120	2422	2725	3028	3331	3634
825	312	624	937	1249	1561	1874	2186	2498	2810	3123	3435	3747
850	322	643	965	1287	1609	1930	2252	2574	2896	3217	3539	3861
875	331	662	994	1325	1656	1987	2318	2650	2981	3319	3643	3974
900	341	681	1022	1363	1703	2044	2385	2725	3066	3407	3747	4088

Note: Flow = Raw Sewage Flow (Flume) + Return Sludge Flow

TABLE NO. D-2

CHART FOR DETERMINING FERRIC CHLORIDE DOSAGE RATE FROM JAR TEST
DOSAGE IN MILLITERS PER MINUTE

Milliliters of 1/50 Ferric Chloride Solution added to the 1 liter sample

Flow	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0	6.5	7.0	7.5	8.0	8.5	9.0	9.5	10.0
400	30	45	61	76	91	106	121	136	151	167	182	197	212	227	242	257	273	288	303
450	34	51	68	85	102	119	136	153	170	187	204	221	238	255	273	290	307	324	341
500	38	57	76	95	114	132	151	170	189	208	227	246	265	284	303	322	341	360	379
550	42	62	83	104	125	146	167	187	208	229	250	271	291	312	333	354	375	396	416
600	45	68	91	114	136	159	182	204	227	250	273	295	318	341	363	386	409	432	454
650	49	74	98	123	148	172	197	221	246	271	295	320	344	369	394	418	443	467	492
700	53	80	106	133	159	186	212	239	265	291	318	344	371	397	424	450	477	503	530
750	57	85	114	142	170	199	227	256	284	312	341	369	397	426	454	483	511	539	568
800	61	91	121	151	182	212	242	273	303	333	363	394	424	454	485	515	545	575	606
850	65	97	129	161	193	225	257	290	322	354	386	418	450	483	515	547	579	611	644
900	68	102	136	170	204	239	273	307	341	375	409	443	477	511	545	577	613	647	681

Note: Flow = Raw Sewage Flow (Flume) + Return Sludge Flow

TABLE NO. D-3

XSU - EXCESS SLUDGE UNITS WASTED PER DAY (in 1,000 SLU)

Based on RSC - Return Sludge Concentration (in %)
and XSF - Excess Waste Sludge Flow (in gpm)

RSC \ XSF	2	4	6	8	10	12	14	16	18	20
7.0	0.202	0.403	0.605	0.806	1.008	1.210	1.411	1.613	1.814	2.016
7.5	0.216	0.432	0.648	0.864	1.080	1.296	1.512	1.728	1.944	2.160
8.0	0.230	0.461	0.692	0.922	1.152	1.382	1.613	1.843	2.074	2.304
8.5	0.245	0.490	0.734	0.979	1.224	1.469	1.714	1.958	2.203	2.448
9.0	0.252	0.518	0.778	1.037	1.296	1.555	1.814	2.074	2.333	2.592
9.5	0.274	0.547	0.821	1.094	1.368	1.642	1.915	2.189	2.462	2.736
10.0	0.288	0.576	0.864	1.152	1.440	1.728	2.016	2.304	2.592	2.880
10.5	0.302	0.605	0.907	1.210	1.512	1.814	2.117	2.419	2.722	3.024
11.0	0.317	0.634	0.950	1.267	1.584	1.901	2.218	2.534	2.851	3.168
11.5	0.331	0.662	0.994	1.325	1.656	1.987	2.318	2.650	2.981	3.312
12.0	0.346	0.691	1.037	1.382	1.728	2.074	2.419	2.765	3.110	3.456
12.5	0.360	0.720	1.080	1.440	1.800	2.160	2.520	2.880	3.240	3.600
13.0	0.374	0.749	1.123	1.498	1.872	2.246	2.621	2.995	3.370	3.744
13.5	0.389	0.778	1.166	1.555	1.944	2.333	2.722	3.110	3.499	3.888
14.0	0.403	0.806	1.210	1.613	2.016	2.419	2.822	3.226	3.629	4.032
14.5	0.418	0.835	1.253	1.670	2.088	2.506	2.923	3.341	3.758	4.176
15.0	0.432	0.864	1.296	1.728	2.160	2.592	3.024	3.456	3.888	4.320
16.0	0.461	0.922	1.382	1.843	2.304	2.765	3.226	3.686	4.147	4.608
17.0	0.490	0.979	1.469	1.958	2.448	2.938	3.427	3.917	4.406	4.896
18.0	0.518	1.037	1.555	2.074	2.592	3.110	3.629	4.147	4.666	5.184
19.0	0.547	1.094	1.642	2.189	2.736	3.283	3.830	4.378	4.925	5.472
20.0	0.576	1.152	1.728	2.304	2.880	3.456	4.032	4.608	5.184	5.760
21.0	0.605	1.210	1.814	2.419	3.024	3.629	4.234	4.838	5.443	6.048
22.0	0.634	1.267	1.901	2.534	3.168	3.802	4.435	5.069	5.702	6.336
23.0	0.662	1.325	1.987	2.650	3.312	3.974	4.637	5.299	5.962	6.624
24.0	0.691	1.382	2.074	2.765	3.456	4.417	4.838	5.530	6.221	6.912
25.0	0.720	1.440	2.160	2.880	3.600	4.320	5.040	5.760	6.480	7.200
26.0	0.749	1.498	2.246	2.995	3.744	4.493	5.242	5.990	6.739	7.488

INSTRUCTIONS TO USE CHART

Given: RSC = 15.0 Wanted 3,000 XSU/Day

1. Determine RSC by centrifuge (15.0)
2. Find RSC in left column, move horizontally to Thousand XSU/Day wanted (3.024)
3. Move vertically to XSF in gpm (14)
4. Set Waste Flow at 14 gpm

FORMULA

XSF in gpm = (69.44) x (Thousand XSU/Day wanted) / (RSC observed)

EXAMPLE

XSF in gpm = (69.44) x (3.0) / (15.0)

XSF in gpm = 13.9

FIGURE E-1

FINAL EFFLUENT BOD 5 AERATION TANK BOD 5 LOAD

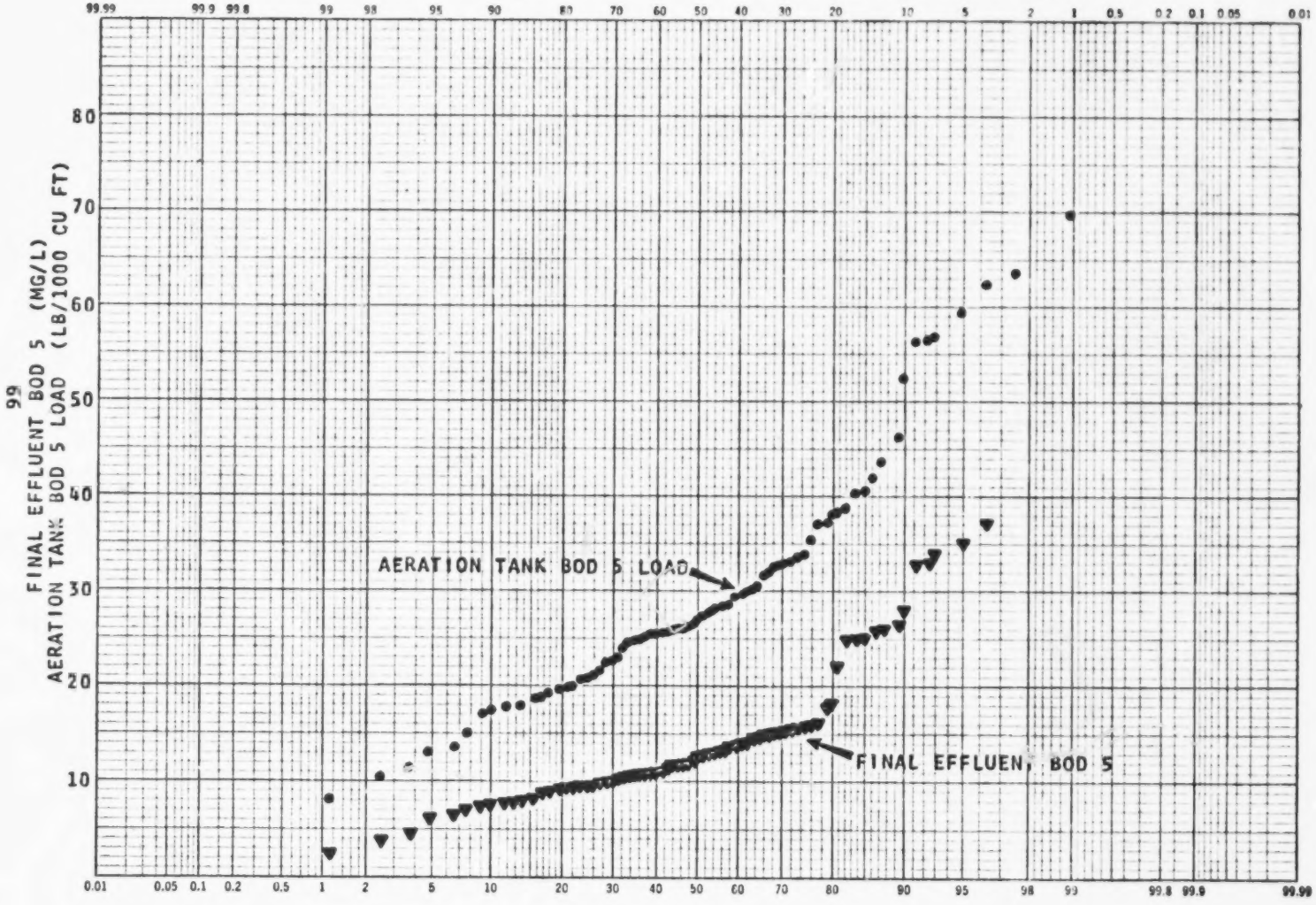


FIGURE E-2

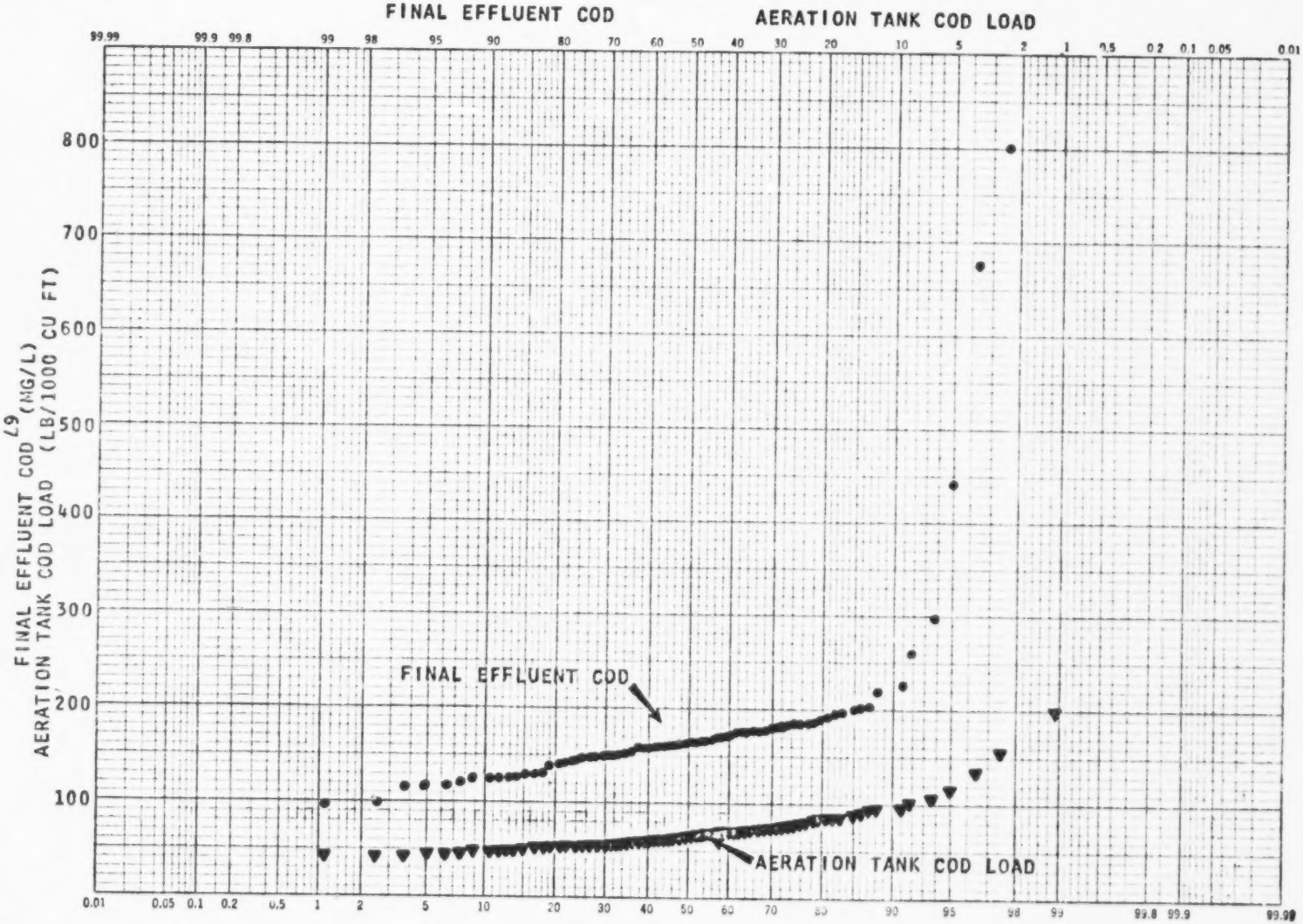

FINAL EFFLUENT COD
AERATION TANK COD LOAD
99.99 99.9 99.8 99 98 95 90 80 70 60 50 40 30 20 10 5 2 1 0.5 0.2 0.1 0.05 0.01
800
700
600
500
400
300
200
100
FINAL EFFLUENT COD (MG/L)
AERATION TANK COD LOAD (LB/1000 CU FT)
FINAL EFFLUENT COD
AERATION TANK COD LOAD
0.01 0.05 0.1 0.2 0.5 1 2 5 10 20 30 40 50 60 70 90 95 98 99 99.8 99.9 99.99

FIGURE E-3

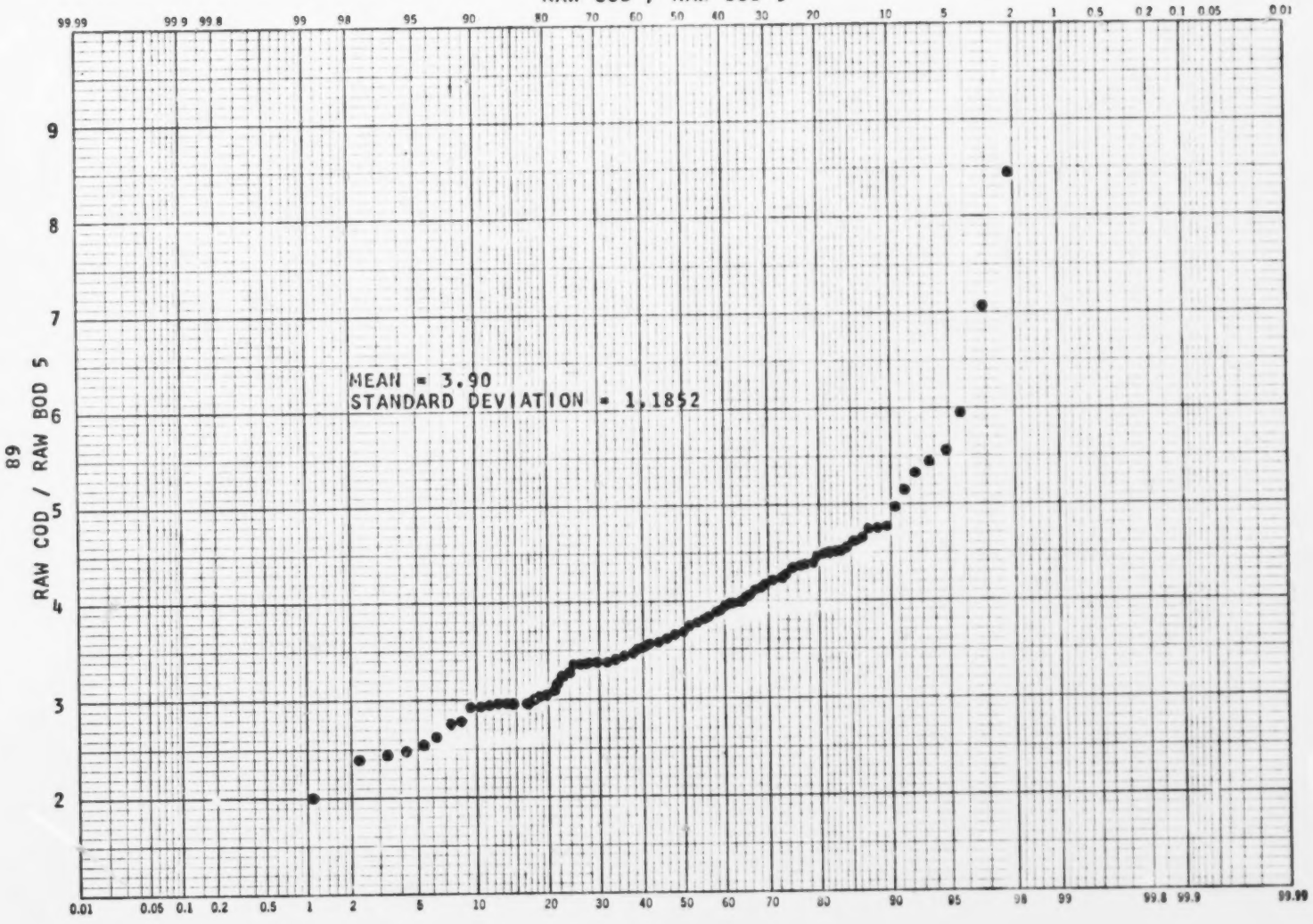

RAW COD / RAW BOD 5
99.99 99.9 99.8 99 98 95 90 80 70 60 50 40 30 20 10 5 2 1 0.5 0.2 0.1 0.05 0.01
RAW COD / RAW BOD 5
89
MEAN = 3.90
STANDARD DEVIATION = 1.1852
2 3 4 5 6 7 8 9
0.01 0.05 0.1 0.2 0.5 1 2 5 10 20 30 40 50 60 70 80 90 95 98 99 99.8 99.9 99.99

FIGURE E-4

P E COD / P E BOD 5

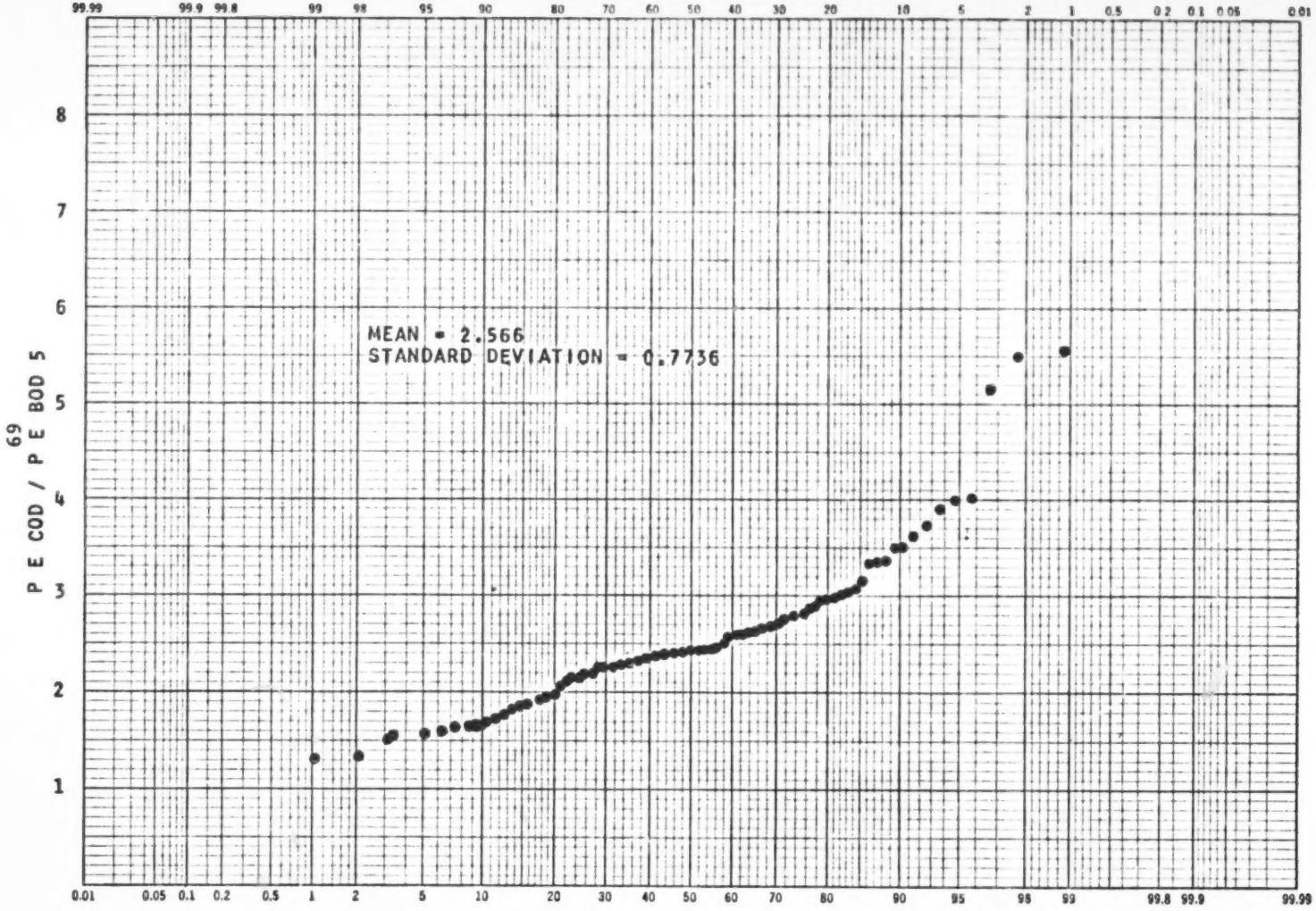
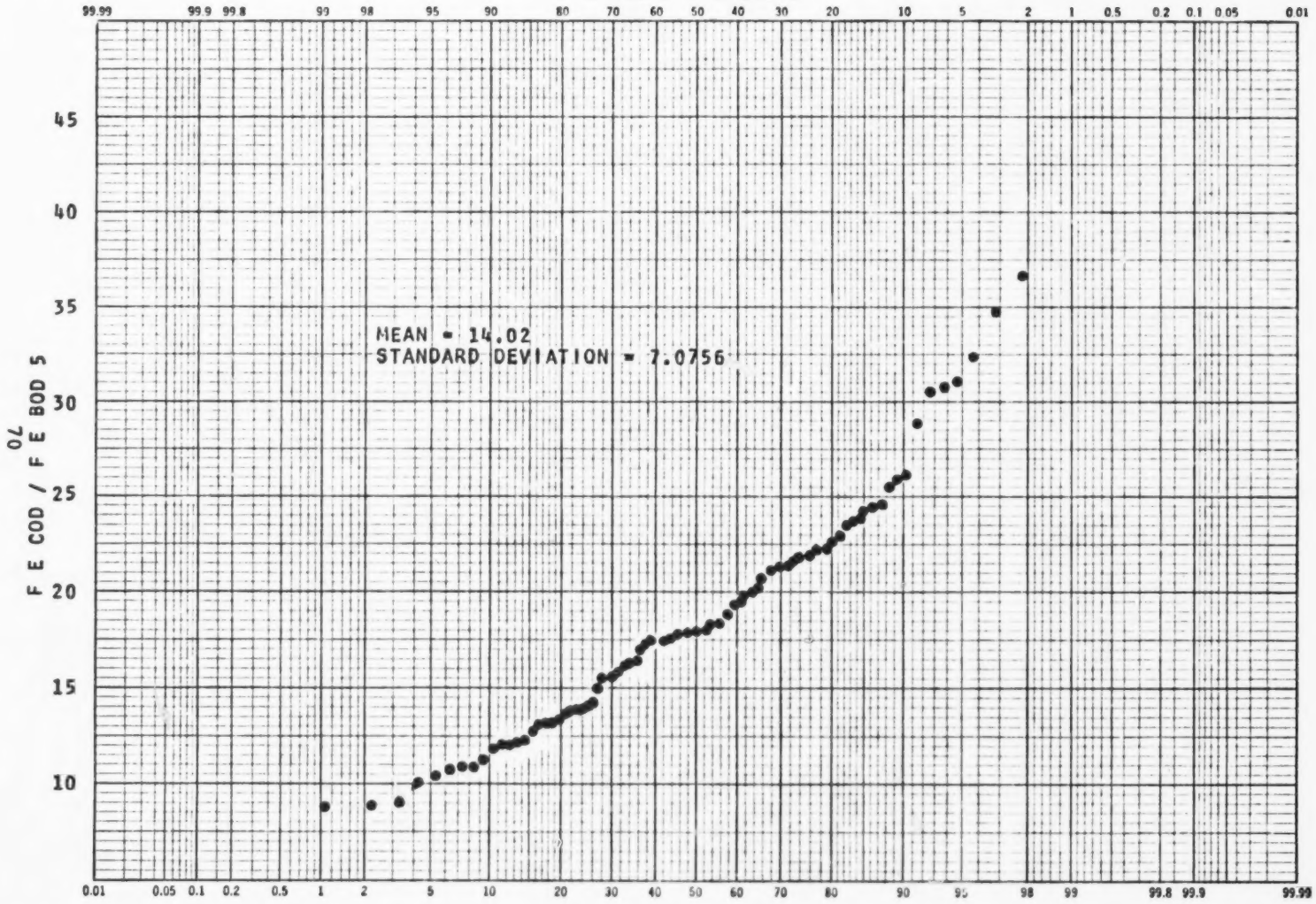


FIGURE E-5


F E COD / F E BOD 5
99.99 99.9 99.8 99 98 95 90 80 70 60 50 40 30 20 10 5 2 1 0.5 0.2 0.1 0.05 0.01
45
40
35
30
25
20
15
10
MEAN = 14.02
STANDARD DEVIATION = 7.0756
F E COD / F E BOD 5
%
0.01 0.05 0.1 0.2 0.5 1 2 5 10 20 30 40 50 60 70 80 90 95 98 99 99.8 99.9 99.99

ABBREVIATIONS

ADT @ AFI	Aeration Detention Time at Aerator Flow In (Primary Effluent)
ADT @ TFL	Aeration Detention Time at Total Flow (Primary Effluent Plus Return Sludge Flow)
AGE	Calculated Sludge Age
ASU	Aerator Sludge Units
ATC	Aeration Tank Concentration (% Volume by Centrifuge)
AV	Aeration Tank Volume
Avg.	Average
BLT	Clarifier Sludge Blanket Thickness
BOD	Biochemical Oxygen Demand (5-Day Unless Stated Otherwise)
BOD 5	5-Day Biochemical Oxygen Demand
CC/L	Cubic Centimeters Per Liter
CFP	Clarifier Sludge Flow Percentage
CM	Centimeter
COD	Chemical Oxygen Demand
Comp. SSC	Composite Settled Sludge Concentration (Without Chemical Addition)
Comp. SSV	Composite Settled Sludge Volume (Without Chemical Addition)
Conf.	Confidence Limit
CSDT	Clarifier Sludge Detention Time

CSF	Clarifier Sludge Flow
CSFD	Clarifier Sludge Flow Demand
CSU	Clarifier Sludge Unit
CU M	Cubic Meters
CU M / DAY	Cubic Meters Per Day
CU M / M	Cubic Meters Per Meter
CU M / MIN	Cubic Meters Per Minute
CU M / SQ M / DAY	Cubic Meters Per Square Meter Per Day
DIA	Diameter
D. O.	Dissolved Oxygen
DOB	Depth Of Sludge Blanket From Clarifier Surface
DOSED SSC	Dosed Settled Sludge Concentration (With Chemical Addition)
DOSED SSV	Dosed Settled Sludge Volume (With Chemical Addition)
F E BOD 5	Final Effluent 5-Day Biochemical Oxygen Demand
F E COD	Final Effluent Chemical Oxygen Demand
FIG.	Figure
FIN. EFFL. BOD 5	Final Effluent 5-Day Biochemical Oxygen Demand
FIN. EFFL. COD	Final Effluent Chemical Oxygen Demand
FLOC. TANK	Flocculation Tank

FT	Feet
GAL / FT	Gallons Per Foot
GAL / SQ FT / DAU	Gallons Per Square Foot Per Day
G BOD 5 / CU M	Grams 5-Day Biochemical Oxygen Demand Per Cubic Meter
G COD / DAY / CU M	Grams Chemical Oxygen Demand Per Day Per Cubic Meter
G / CU M	Grams Per Cubic Meter
GPM	Gallons Per Minute
HR / DAY	Hours Per Day
IN	Inches
JTU	Jackson Turbidity Units
k	Deoxygenation Constant
KG / DAY	Kilograms Per Day
LB BOD 5 / 1000 CU FT	Pounds 5-Day Biochemical Oxygen Demand Per 1000 Cubic Feet
LB COD / DAY / 1000 CU FT	Pounds Chemical Oxygen Demand Per 1000 Cubic Feet Per Day
LB / DAY	Pounds Per Day
LB / DAY / 1000 CU FT	Pounds Per Day Per 1000 Cubic Feet
LB / K CU FT	Pounds Per 1000 Cubic Feet
L / SEC	Liters Per Second
M	Meters
MGD	Million Gallons Per Day
MG / L	Milligrams Per Liter

MG / L / MIN	Milligrams Per Liter Per Minute
ML / LITER	Milliliters Per Liter
ML / MIN	Milliliters Per Minute
MLTSS	Mixed Liquor Total Suspended Solids
MLVSS	Mixed Liquor Volatile Suspended Solids
NFIC - C	National Field Investigation Center Cincinnati
NO.	Number
OCF	Owens-Corning Fiberglas Corporation
OFR	Overflow Rate
P	Phosphorus
P. C.	Primary Clarifier
PDT	Primary Clarifier Detention Time
P E	Primary Effluent
PRI.	Primary
PRI EFFL BOD 5	Primary Effluent 5-Day Biochemical Oxygen Demand
PRI EFFL COD	Primary Effluent Chemical Oxygen Demand
PSF	Primary Sludge Flow (To Digester)
RPM	Revolutions Per Minute
RSC	Return Sludge Concentration (% Volume By Centrifuge)
RSF	Return Sludge Flow

RSFD	Return Sludge Flow Demand
RSTSS	Return Sludge Total Suspended Solids
RSU / 1000 AFI	Return Sludge Units Per 1000 Gallons Aerator Influent Flow
RSU / 1000 GAL	Return Sludge Units Per 1000 Gallons
RSVSS	Return Sludge Volatile Suspended Solids
SCR	Sludge Concentration Ratio
SDR	Sludge Distribution Ratio
SLR	Sludge Ratio
SLU	Sludge Unit
SQ FT	Square Feet
SQ M	Square Meters
SS	Total Suspended Solids
SSC	Settled Sludge Concentration
SSC 0	Settled Sludge Concentration At Time Zero (ATC)
SSC 60	Settled Sludge Concentration At Time Equal Sixty Minutes
SSV	Settled Sludge Volume
SSV 5	Five Minute Settled Sludge Volume
SSV 60	Sixty Minute Settled Sludge Volume

TFL	Total Flow (Primary Effluent Plus Return Sludge Flows)
TSS	Total Suspended Solids
TSU	Total Sludge Units
WCR	Weight to Concentration Ratio
WT MLTSS / WT WASTE SS / DAY	Weight Of Mixed Liquor Total Suspended Solids Per Weight Of Suspended Solids Wasted Per Day
WT P E BOD	Weight Of Primary Effluent 5-Day Biochemical Oxygen Demand
WT PE COD	Weight Of Primary Effluent Chemical Oxygen Demand
WT PE TSS	Weight Of Primary Effluent Total Suspended Solids
WT SOLIDS GEN / WT BOD 5	Weight Of Solids Generated Per Weight Of 5-Day P E Biochemical Oxygen Demand
WT SOLIDS GEN / WT COD	Weight Of Suspended Solids Generated Per Weight Of P E Chemical Oxygen Demand
XSF	Excess Sludge Flow To Waste
XSU / DAY	Excess Sludge Units To Waste Per Day

G-1

ANDERSON WASTE CHARACTERIZATION

The sources and characteristics of wastewater from the Anderson plant are variable and quite complex. At the present time, nearly 100 formulations are used to bond individual glass fibers into glass strand. The principal base materials are polyesters, polyvinyl acetates, expoxies and starch. All of the binders combine the base material with an emulsifier to form a water dispersable emulsion. Other water sources dilute these emulsions to give the waste a milky appearance. The following data summarizes the waste sources and the approximate percentage of flow.

Source	% of Total Flow
Binder Application and Washdown	25
Resin Manufacture	15
Air Scrubbers	20
Cooling Water Blowdown	1
Sanitary	13
Reinforced Mat Production	26

The principal sources of organic contamination are the binder application, washdown, and the polyester resin manufacturing. Since it is nearly impossible to analyze a specific waste stream for individual chemical components, specific chemical dumps were tabulated during the period of the EPA study. This data, combined with information on specific process efficiencies, yields the following approximate breakdown of the organic fractions.

Polyvinyl Acetate	26%
Polyester	27%
Starch	14%
Epoxide	5%
Silicone	5%
Oil	4%
Aromatic Polyether	5%
Polyolefin	2%
Acetic Acid	1%
Polyurethane	2%
Poly(oxy)ethylene Glycol	3%
Polyvinylpryollidone	2%
	96%

Fractional organics include waxes, aromatic nonionic surfactants, citric acid, polyvinyl alcohol, gelatin, fatty acid amide, and various cleaning solvents.

In addition to the binder components, the treatment plant must also handle cleaning and upset wastes. During the EPA Study, the following quantities of these wastes were noted:

Ammonium Hydroxide	550 lbs.
Sodium Hydroxide	8870 lbs.
Maleic Acid	2000 lbs.

It should be noted that the above data is specific to the Anderson plant. It cannot be generalized for the textile Fiberglas industry.

NOTE: This Appendix G was furnished by the Owens-Corning Fiberglas Corporation.

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